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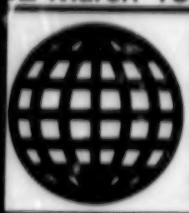

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JPRS Report

Science & Technology

Central Eurasia: Space

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JPRS-USP-94-003 22 March 1994

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Development of Soyuz Spacecraft Recalled

947Q0080B Moscow NEZAVISIMAYA GAZETA in Russian 15 Jan 94 p 6

[Article by Dmitriy Payson: "Eternal 'Soyuz'—Today Marks the 25th Anniversary of the First Docking in Orbit"]

[Text] Strictly speaking, 1969 became the Year of the Moon because on the evening of 20 July Neil Armstrong strode across the basalt of the Mare Tranquillitatis and the Americans finally broke ahead in the space race.

In addition, January 1969 was the apotheosis of our country's lunar program. The unmanned Zonds were launched to the moon, one after another; it was necessary to overtake the Americans, the first to send an astronaut flying around the moon. And another modification of this same ship, designated the Soyuz, had to be tested in circumterrestrial orbit on an accelerated schedule.

The Korolev Design Bureau began to work on the Soyuz—a lunar ship and the future universal "carrier"—virtually simultaneously with the successful flights of the first cosmonauts. On 23 April 1967—1 ½ years prior to the first manned Apollo flight—Vladimir Komarov piloted the first Soyuz. On the very next day the "solemn tribute" to the anniversary of Lenin's birth ended in a tragedy. The Soyuz was hastily prepared for launching and it was launched (an unprecedented act!) despite the categorical refusal of Vasiliy Mishin, replacing Korolev, and it literally "came apart at the seams." Engineer-colonel Vladimir Komarov perished.

For 1 ½ years the Soyuz stuck in the mind. Yuriy Gagarin was forbidden to fly in the second vehicle. And in October 1968, this time without linking it to glorious anniversaries, Georgiy Beregovoy, an assault aircraft pilot during the Great Fatherland War, successfully landed the third Soyuz. To be sure, prior to this not being able to dock the ship with the automatic Soyuz 2.

It all boiled down to this; not being able to perform docking in orbit, it was better not to push on to the moon. Both Soviet and American lunar ships while "in flight" had to link up with the cabin with cosmonauts or astronauts "lifting off" from the moon. If a docking did not take place, only a miracle could save those who had trodden on the moon. Accordingly, on our country's lunar ship the docking system was simplified to the limit. The pilot of the lunar Soyuz in one way or another had to insert the docking unit shaft into one of several openings in the receiving unit, the "meat grinder," as the strange holey structure was called, of the lunar cabin. After linking of the ships the lunar cabin pilot returned "home" through open space.

This had to be done by Aleksey Yeliseyev and Yevgeniy Khrunov on 15 January. They put into orbit the Soyuz 5 under the command of Boris Volynov, and there Vladimir Shatalov already waited in the Soyuz 4.

Unfortunately, we can visualize the world's first docking of two manned ships only from drawings and models. It is easy to understand that there was no one to photograph the cosmonauts creeping along the handrails. It was decided to correct this during the next launchings. Three Soyuz ships—11, 12 and 13—were launched in October 1969 with an interval of one day. Two of them were to make a docking, whereas the third was to approach them as close as possible and survey all the "acrobatics." Alas, the ships could not approach one another and the attainments of the "cosmic escadrille," in addition to a hitherto unprecedented "population density" in orbit, were limited to the world's first welding experiment in space, which was performed by Valeriy Kubasov.

The first docking was a happy event for its participants. None of them, other than Yevgeniy Khrunov (who, according to some information, headed a secret detachment of cosmonauts for flights in the Spiral spaceplane), never again headed into space. Boris Volynov became a strong commander of a detachment of a new group of cosmonauts. Vladimir Shatalov received the stars of a general and headed the training of Soviet cosmonauts. Aleksey Yeliseyev directed flights at the Flight Control Center, but later at Moscow Higher Technical School imeni Bauman.

Although the Soyuz did not deliver cosmonauts to the moon, it remained virtually "eternal." Thereafter it was repeatedly modified—it was designated the Soyuz T and the Soyuz TM; was launched in a cargo variant as the Progress; as a small module for orbital stations under the name Gamma. It remains on line even now, delivering cosmonauts to the Mir station. And the Americans, who have successfully developed and operated the heavy Space Shuttle, proceeding right up to construction of the Freedom orbital station, have begun to negotiate with the Russian NPO Energiya on use of the Soyuz as a rescue ship.

Commentary on Soyuz Collision With Mir Station

947Q0080A Moscow ROSSIYSKIYE VESTI in Russian 21 Jan 94 p 8

[Article by Vadim Chernobrov: "Collision in Space"]

[Text] When the image on the television screens sharply trembled the surface personnel at the Flight Control Center at once held their breath. What our cosmonauts in orbit felt at this moment only they know. The Soyuz TM-17 spaceship at an altitude 300 km had collided with the Mir orbital complex. Such accidents, before this described only in science fiction and not happening except in one's dreams, are extremely dangerous because a ship, experiencing rupture, very rapidly loses its air, which results in the inevitable death of the crew. It goes without saying that the air does not instantaneously escape into space and the crew for their salvation is left

a safety window from 1-2 seconds to several minutes, depending on the size of the rupture and the air volume in the cabin.

The cosmonauts, who, as is well known, are characterized by excellent reflexes, at the time of the collision already were in spacesuits and so it was that they only had to lift up an arm, make the helmet tight and make their airtight gloves secure. The variant of a landing in a depressurized ship had already been repeatedly practiced (the death of a crew of three men in 1971 due to the depressurization of the Soyuz 11 descent module had been able to teach us something), but no one could guarantee that the descent module would not itself be damaged during a collision. Incidentally, the principal impact on the Soyuz occurred precisely on the thick heat insulation of the skin of this compartment. And, happily, after this no one heard the ominous whistling of air. The walls of both vehicles withstood the impact...

As the specialists at the Flight Control Center informed us, for several minutes the Soyuz landing was in question. Then when it became clear that the heat insulation had not been damaged (which would have threatened ship burnup during descent) and that the impact did not extend through to the cover of the parachute compartment (otherwise it could have jammed) it was decided to land the Soyuz TM-17. This also was done beautifully.

"Information on what occurred will be analyzed by a special technical commission, which also will draw the necessary conclusions concerning the possible consequences of a collision," declared Aleksandr Serebrov, the expedition's engineer, immediately upon return. In the opinion of the cosmonauts who had been in orbit, the station, leaving aside a brief shutdown of the gyrodynes, also did not suffer, and as was planned, will be able to exist right up to the putting of the first functional units of the Alpha station into orbit. According to preliminary information, the reason for the collision was the untimely switching from automatic to manual control at a time when the Soyuz began to rotate slowly near the Kristall module. The crew intended to fly around the station for an inspection, but feeling the jolt fired the orientation engines and moved away.

Conflicting Versions of Mir Collision Incident

947Q0077 Moscow SEGODNYA in Russian 26 Jan 94 p 1

[Article by M. Chernyshev, under the rubric "Details": "Was the Incident in Space an Accident? Awards Were Given Before the State Commission Drew Its Conclusions"]

[Text] While the State Commission is still in session investigating the recent incident in space in which Vasiliy Tsibliyev and Aleksandr Serebrov, who had turned over the reins to the new inhabitants of Mir, almost rammed their old living quarters as they flew by it after undocking the transport craft from the station, the cosmonauts have already been given high state awards for the flight. It's the opinion of specialists from the Control Center that it would have been more logical to wait until the investigation ended: what if the main cause for the incident was pilot error? The plan for time immemorial after the transport craft undocks from Mir has been that it fly around the station to inspect the exterior, says Viktor Blagov, the deputy flight director. During the fly-around, the transport craft got too close to the station. It seems that a light, glancing blow occurred. The response of the crew of Vasiliy Tsibliyev and Aleksandr Serebrov was adequate.

"Had it been otherwise, would the result of the collision have been different?"

"It would have been about the same."

At worst, the station would have been punctured, which still wouldn't have meant a tragic outcome. Orbital craft are designed the way submarines are, that is, they're made up of sealed compartments. The arguments of the specialists are, perhaps, convincing, but also contradictory: according to the first reports from the Control Center, the problem involved possible damage to the docking assembly; then it was a glancing blow; and finally the most recent version—no collision occurred at all. The most surprising thing about the story is that the people directly involved in it have, to this day, no information at all.

"There are some interpretations of the telemetry, but nobody's telling us anything about it," said Aleksandr Serebrov in a telephone conversation.

At NPO Energiya, to this day there are several versions of what happened. There was a collision, reports one specialist who should know, but they haven't been able to determine exactly where Mir was hit. In a fly-around the station by the new crew, no damage was seen. But just to make sure, a plan is being drawn up for the cosmonauts to make an EVA to make a careful inspection of the exterior.

Technical problems, errors in planning, irresponsible actions by those executing tasks—all those things are cropping up in this country's spaceflight and are approaching critical mass.

Physician German Arzamazov, on the eve of the fifteenth mission to the Mir orbital station, caused a scandal and quit his job in the backup crew. The always emotionally reserved mission director Vladimir Solovyev has announced that the Control Center in Kaliningrad outside of Moscow is having to do extra work because the most basic order is lacking at Baykonur.

Role of Cosmonaut Krikalev on U.S. Shuttle Flight Discussed

947Q0084 Moscow NEZAVISIMAYA GAZETA in Russian 2 Feb 94 p 6

[Article by Dmitriy Payson, under the rubric "Cooperation": "Russian Cosmonaut Aboard the 'Shuttle': Sergey Krikalev Becomes a Full-Fledged Member of the Crew"]

[Text] On Thursday, 3 February, the Russian cosmonaut Sergey Krikalev is to be sent into space aboard the "space shuttle" Discovery.

Our cosmonauts have not met with the Americans in orbit since the joint flight of Soyuz and Apollo in 1975. Although a joint Shuttle-Salyut flight was planned after Soyuz-Apollo, the agreement was cancelled because of a worsening of the political climate, and the meeting of the cosmonauts and astronauts in orbit was postponed indefinitely.

After the Soviet-American "handshake in orbit," cosmonauts from the entire socialist camp went into space aboard the Soyuzes. The American Shuttle crews included specialists not only from Western Europe, but also from Mexico and Saudi Arabia.

Sergey Krikalev, however, will not be a "diplomatic representative" of Russia in the intensely working crew. An engineer from NPO Energiya, an acrobatic pilot, and an experienced specialist in EVAs, Krikalev is departing on the flight as a full-fledged crew member—a flight program specialist. The five astronauts and one cosmonaut are to place into orbit a platform for growing ultrapure semiconductor crystals and then bring it back aboard Discovery after completion of the experiments.

Krikalev trained for a little more than a year in the American Johnson Space Center, working with the Shuttle's remote manipulator. Now, using the "mechanical arm," he is to get the saucerlike platform from the cargo bay of the craft and bring it back later. "It's similar to the manual control of the Soyuz," Krikalev said, speaking of the work with the manipulator. "They say you 'fly' the 'arm' more than you control it." In the words of cosmonaut-astronaut Krikalev, you can generally acquire the skills for working with such manipulators by even, well, playing computer games—racing airplanes or a "digger" on the screen. There it is—the benefit of the "dandyization" of society!

In addition to the work with the "flying saucers," the crew will work in the commercial laboratory Spacelab, which is set up in the cargo bay. Spacelab is a fairly small additional compartment that roughly doubles the usable space of the Shuttle cabin. Of course, the weeklong flight with such an "add-on" can't be compared with ever so longer flights on the orbital station. So the flight of Krikalev and the flight of his backup, Vladimir Titov, planned for February 1995 about the Shuttle, are serving the role of prelude to the first stage of the Russian-American cooperation in the creation of the joint orbital station Alpha, as they're calling it for now. And in 1995, an American astronaut will go up to the Mir station for three months.

Of course, the flight of Sergey Krikalev is no pioneering achievement. The launch slated for tomorrow will be the 60th launch of a Shuttle, and Krikalev himself has 464 days aboard Mir. But the political importance of the work of this kind is unquestionable. The Russians and the Americans are learning to work together. The future orbital station couldn't be built without it.

Academy Observatory in the Northern Caucasus

947Q0089 Moscow VESTNIK ROSSIYSKOY AKADEMII NAUK in Russian Vol 63, No 9, Sep 93 pp 790-794

[Article by Academician Yuriy Nikolayevich Pariyskiy, deputy director of the Special Astrophysical Observatory, Russian Academy of Sciences; Viktor Leonidovich Afanasyev, doctor of physical-mathematical sciences and director of the Special Astrophysical Observatory]

[Abstract] The Russian Academy of Sciences Special Astrophysical Observatory—located in the Northern Caucasus, 25 km from Zelenchukskaya Station, in the mountains of Karachayevo-Cherkessiya—is the largest such observatory in Russia. It has the world's largest optical telescope (6 meters) and the world's largest radiotelescope (the 600-meter RATAN-600). Together, the two telescopes can perform virtually any ground-based astrophysical experiment in the optical, centimeter, and decimeter ranges. The 6-meter telescope is used to study number of phenomena, including the chemical composition, magnetic fields, and atmospheres of stars and the spectral and polarimetric characteristics of relativistic objects such as black holes and neutron stars. The RATAN-600 has a wide range of uses, such as studies of the interstellar medium and star formation. More than 20 organizations from Russia and the near-abroad make use of the RATAN-600, and in 1989 alone, it found 14,000 objects. Like other facilities of the Academy of Sciences, however, the observatory is having difficulty getting money for even minimum maintenance. The RATAN-600 is particularly troubled in that regard and has been operating at 10-percent capacity in recent months. Figures 2, references 2 (Russian).

Problems in Radio Engineering and Radio Physics (1984-1992)

947Q0083A Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 38 No 10, Oct 93 pp 1734-1750

[Article by N. A. Armand and K. I. Palatov, Radio Engineering and Electronics Institute, Russian Academy of Sciences]

[Abstract] The last summary of research activity of the Radio Engineering and Electronics Institute, Russian Academy of Sciences, covered the years 1983-1984. This review covers the years 1984-1992 inclusive and the most significant results obtained in each of the fields and subjects listed below are summarized. 1. Planetary radar and space radio physics (mapping of Venus by Venera 15 and Venera 16; study of Halley's comet (Vega project); study of Venusian atmosphere and ionosphere; study of the solar wind; study of physical conditions on Mars in connection with the "Fobos" project; radar observation of planets for checking accuracy of the relativistic theory of motion of planets; study of near space using artificial earth satellites). 2. Remote sensing of atmosphere and surface (study of electromagnetic emissions of different surface cover types in microwave range; active (radar) methods for remote sensing of atmosphere and surface; ecological and climatological aspects of remote sensing of land surfaces; remote sensing of ocean floor). 3. Radio wave propagation (propagation of radio waves in millimeter range; propagation of optical waves in atmosphere; study of atmosphere as medium for radio wave propagation). 4. Statistical radio physics (study of ULF and UHF electromagnetic noise (study of natural ULF and UHF electromagnetic fields; research on stochastic electromagnetic processes; study of complex signals and conditions for their discrimination from noise; development of analyzers of natural fields and weak signals and instruments for detecting earthquake precursors). 5. Electrodynamics of artificial media and structure in microwave range (electrodynamics of microwave antennas, resonators and waveguide elements; materials for microwave range (highly absorbing and with small losses; diffraction problems in microwave range).

Radar Observations of Asteroid 4179 Toutatis at Wavelength 6 cm

947Q0083B Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 38, No 10, Oct 93 pp 1842-1850

[Article by A. L. Zaytsev, A. G. Sokolskiy, O. R. Rzhiga, A. S. Vyshlov, A. P. Krivtsov and V. A. Shubin; UDC 621.396.96:523.6]

[Abstract] Precise radar observations of the asteroid 4179 (Toutatis) were made on 8 and 9 December 1992 when the asteroid approached the Earth to within a minimum distance of 3.6 million km. The asteroid, discovered in 1986 by French astronomers, can be identified with 1934 CT, discovered in 1934 but then lost. The angle between the orbital planes of the Earth and Toutatis is only 0.46° and it constitutes a potential danger to the Earth. Radar measurements of the Doppler shift of echo signals made possible a substantial improvement in the orbital parameters, an increase in the reliability of prediction of orbital motion and an evaluation of the degree of danger of collision during its periodic approaches to the Earth. The supplementation of the 136 optical observations of the asteroid made between 1934 and 1992 by recent radar data reduced the prediction error for 29 September 2004 when the asteroid will approach the Earth to a distance of 0.01 AE. An analysis of the spectra of reflected signals revealed that this is a double asteroid consisting of approximately equal bodies which are in close contact. An estimate of the period of asteroid rotation made using measurements of the spectral width of the echo signal on the assumption that the axis of rotation is normal to the line of sight suggests rotation with a period 5.7...6.5 days. The radar albedo of the asteroid is 0.08 if its radius is 2 km. Its surface characteristics were determined, as were the polarization ratio and radar cross section. The asteroid will be within the limits of accessibility of national radar apparatus at the time of successive approaches in 1996, 2000 and 2004. Figures 5; references 12: 5 Russian, 7 Western.

Two Methods for Satellite Measurements of Outgoing Radiation Fluxes

947Q0079A Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 93 pp 3-11

[Article by Yu. A. Sklyarov, Yu. I. Brichkov and V. A. Vorobyev, Saratov State University imen. N. G. Chernyshevskiy; UDC 528.83]

[Abstract] Two methods for satellite measurements of outgoing radiation fluxes are examined (with scanning narrow-angle and nonscanning wide-angle radiometers) in connection with determination of the Earth's radiation budget, requiring a knowledge of the mean intensity of radiation over extensive areas. The problems involved in processing the measured quantities for determining the outgoing radiation fluxes are discussed and a comparative analysis of the measuring capabilities of both methods is presented. It is shown that measurements made with scanners are inferior to wide-angle radiometers. A wide-angle radiometer immediately registers the instantaneous mean value of outgoing radiation over a great area, whereas scanners give a better result when it is necessary to obtain a more detailed regional distribution of outgoing radiation (in grid units measuring 2.5 x 2.5°). The color effect arising due to the difference in the spectral composition of radiation between the calibration target and the object is much greater for a scanner. A wide-angle radiometer operating in the SW range can be calibrated quite simply directly in ordinary actinometric units, whereas the calibration procedure is extremely complex for scanners and must be accomplished virtually continuously, a serious source of errors. The scanner is structurally more complex, whereas wide-angle radiometers are simpler in design and operation and have a longer useful life and provide an accuracy in determining budget parameters equal to scanner determinations. However, it is concluded that both types of instruments (scanning and wide-angle radiometers) effectively supplement one another. References 15: 8 Russian, 7 Western.

Influence of Aerosol Atmosphere on Colorimetric Characteristics of Water Surfaces in Space Observation

947Q0079B Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 93 pp 12-18

[Article by Sh. A. Akhmedov and N. A. Agayev, Azerbaijan National Aerospace Agency, Baku; UDC 551.521:629.195]

[Abstract] A study was made of the spectral properties of the atmospheric transfer function, on the basis of the color tones and saturation of surface features observed from spaceships making it possible to ascertain their colorimetric characteristics at the surface. The findings are illustrated by the results of computations of the colorimetric characteristics of the eastern shores of the Caspian Sea and uniform water surfaces for the case of a molecular atmosphere in the presence of ozone and a molecular atmosphere in the presence of aerosol and ozone for three observation angles (0, 30, 60°) with a change in solar zenith distance from 0 to 60°. For a uniform water surface the transfer functions always have greater values than those for the shores. With the addition of scattering particles (aerosols) to a molecular atmosphere in the presence of ozone the values of the transfer functions for the color coefficients X and Y increase, whereas those for Z decrease. When the atmosphere is polluted by aerosol particles the role of scattering particles in the transformation of surface colorimetric characteristics substantially increases. The results indicate that the colorimetric characteristics observed from space are dependent not only on the relation among the optical parameters of aerosol, but also are determined by the conditions of atmospheric illumination by direct solar radiation. Figure 1; references: 11 Russian.

Allowance for Influence of Waves and Cloud Cover in Measurements of Ocean Surface Temperature From Artificial Earth Satellites by Microwave-Spectrometer Method

947Q0079C Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 93 pp 26-31

[Article by A. G. Grankov, Radio Engineering and Electronics Institute, Russian Academy of Sciences, Moscow; UDC 551.463:629.78]

[Abstract] In an earlier study by the author (ZHURN TEKHN. FIZIKI, Vol 60, No 10, pp 114-120, 1990) it is proposed that the position of the sensitivity maximum of the radiation field to OST (ocean surface temperature) be used instead of radio emission intensity as a quantitative OST characteristic. The effectiveness of the proposed microwave spectrometer method for determining OST in the presence of waves and cloud cover is analyzed on the basis of the dependence of OST of a calm water surface on the position of the spectral sensitivity maximum of the field of natural microwave radiation to OST variations. With variation of OST in the range of natural variability of the world ocean (from 0 to 30°) the parameter λ_m (wavelength) changes from 8.5 to 3.5 cm respectively. The limiting heights of waves and cloud cover densities within which the method retains stability and ensures the required accuracy are determined. Tabulated data show that the microwave spectrometer method, applied in the form of a very simple algorithm, when the wind speed is up to 5-7 m/s has an accuracy in determining OST of about 1°C. An improved method is proposed which makes it possible to double or triple the range of meteorological conditions within which the error in determining OST does not exceed 1°C. The presence of well-developed cloud cover and foam formation on the water surface causes a considerable increase in the error in determining OST. Ocean areas with such conditions must be excluded from further examination or subjected to more complex processing. Figures 3; references: 6 Russian.

Use of Hough Transform in Processing of Radar Images

947Q0079D Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 93 pp 33-39

[Article by N. V. Rodionova, Radio Engineering and Electronics Institute, Russian Academy of Sciences; UDC 528.852.8]

[Abstract] In image analysis important information on a feature is frequently contained in its boundaries. In many cases for the identification of a feature it is sufficient to analyze only its contour image, as first proposed by P. V. C. Hough. The Hough transform is effective in the secondary processing of radar images and this is illustrated in the example of identification of linear features. The Hough transform is applicable in many such problems, such as in remote prospecting for minerals and detection of the tracks of ships on radar images and distinguishing the tracks of ships from other linear oceanic features created by submarine topography and also in detecting ship size and its direction and speed of movement. However, emphasis here is on detection of a moving point target against the background of strong noise. The tracks of targets moving at a constant velocity are straight lines which can be detected using the Hough transform. The motion and direction of the target track, as well as the current position of the target, can be determined by this method. The principal advantage of use of this transform is its relative insensitivity to noise and gaps in contours. Matrix processors for performing the Hough transform with parallel processing on an on-line basis usable in both surface systems for processing images and aboard satellites have now been developed. Figures 3; references 13: 1 Russian, 12 Western.

Almaz 1 Spacecraft - 'Okean-I' Program: Preliminary Results of High-Resolution Radar Observation of Oceanic Processes. Internal Waves

947Q0079E Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 93 pp 63-75

[Article by V. V. Viter, G. A. Yefremov, A. Yu. Ivanov, K. Ts. Litovchenko, S. S. Semenov, A. V. Smirnov, Yu. G. Trokhimovskiy. P. A. Shirokov and V. S. Etkin, NPO Mashinostroyeniya, Reutov, Moscow Oblast; Space Research Institute, Russian Academy of Sciences, Moscow; UDC 551.446.8:629.78]

[Abstract] The "Okean-I" scientific research program was drawn up during preparations for launch of the Almaz 1 spacecraft for supplementing the results of experiments with the Cosmos 1870 artificial satellite. The program objective was further development of radiophysical methods for study of the ocean, study of the generation and propagation of surface gravity and gravity-capillary waves and evaluation of the information yield of radar data for diagnosis and study of various oceanic processes. The preliminary results obtained using a synthetic aperture radar are given. Data from subsatellite experiments (from flying laboratories and research ships) are analyzed (Kamchatka, Gulf Stream, NAECS, Pre-Cheri and Almaz 1/ERS 1 experiments, each of which is described). Detailed information is given for the following regions: Kamchatka; northwestern part of Lake Ladoga, Duiker Point near Cape Town; sea area to west of Kara Strait; Oshima volcanic island; Cape Shipunskiy; Sea of Okhotsk to north of Urup Island. Among the new results obtained were the following: generation of internal waves was discovered in the thermocline (in Lake Ladoga), caused by an atmospheric disturbance, and also from a "point" source (in the Kara Strait region) accompanying flow of a current around an underwater cape; surface manifestations of internal waves were observed in a number of new regions (South African shelf, around the Japanese islands and elsewhere). Figures 7; references 13: 6 Russian, 7 Western.

Atmospheric Indicators of Near East Earthquakes

947Q0079F Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 6, Nov-Dec 93 pp 81-83

[Article by L. I. Morozova, Geology and Geophysics Institute, Uzbek Academy of Sciences, Tashkent; UDC 528.871]

[Abstract] An analysis of imagery from the NOAA 11 and NOAA 12 satellites (scale 1:25 000 000) revealed cloud anomalies over faults near the epicenters of earthquakes in Armenia in December 1988 and in Turkey in March-April 1992. No allowance is made for the possibility of influence of gravity fields. Two photographs showing the pattern of cloud cover at the time of these events are interpreted. The appearance of these cloud anomalies gives evidence of an intensification of tectonic activity in these regions. For example, the geometry of the cloud lineament accompanying the Spitak earthquake rigorously corresponds to the pattern of faults at the surface and therefore this lineament unquestionably is associated with crustal faults. Other cloud phenomena included ridges, corridors without clouds and sharply defined boundaries of cloud masses. Much the same was observed during seismic events occurring in Turkey. The fact that strong earthquakes in the Near East were accompanied by an atmospheric reaction registered on space imagery inspires hope that this phenomenon can be used in evaluating the tectonic activity of regions or, in a special case, seismicity. The interrelationship of the largest faults in the Near East, repeatedly generating catastrophic earthquakes, as revealed in the studied space photographs, further confirms the results given earlier by V. G. Trifonov, et al. in GEOTEKTONIKA, No 6, pp 46-60, 1990. Figures 2; references 4 Russian.

Russia's Space Plans to End of Decade

947Q0088 Moscow ZEMLYA I VSELENNAYA in Russian No 5, Sep-Oct 93 pp 3-11

[Article by V. V. Alaverdov, Yu. N. Koptev, V. I. Lukyashchenko, V. P. Senkevich, V. F. Utkin, Russian Space Agency, Central Scientific Research Institute of Machine Building: "Russia in Space: This Decade"]

[Text]

Space Exploration in the World and in Our Country

The twentieth century brought many extraordinary events, and one of the greatest events was mankind's going beyond the bounds of Earth. Time will pass, and much will be forgotten, but the first manned flights into space will always be remembered.

In an unusually short period of time, space exploration has become an area of concentration of the latest achievements of mankind, the apex of scientific-technical progress, and a powerful practical means for solving the most varied of problems, problems that are often of a global scale. Now the space program is making a very real contribution to the economy and culture, and it is playing an essential role in securing the safety of the state, in disseminating information to society, in monitoring the environment, and in solving vitally important social problems.

In the first decade of the space age, only the USSR and the United States had a space potential of their own that made it possible to effect the entire cycle from development and launch of space vehicles to the practical use of results; now 17 countries are launching their own satellites, and, by 1995, that number is expected to grow to 20-25. In all, though, more than 130 countries participate in space activity either directly or indirectly.

Our space program right now is undergoing profound reform, as is the entire economy of the country. The reform of the space sector entails primarily the development of a new concept and a long-term policy and program for Russia's space activity, plus the realization of new economic relations, a defense doctrine, and the interests of domestic and foreign consumers, including the states of the CIS. In the process, it is vitally important that the space- related scientific-technical and intellectual potential that has been created be preserved and be used effectively. Legislation regulating space activity also needs to be enacted.

The year 1992 was a difficult year for our space program. Because of the sharp drop in orders for space hardware, space-industry enterprises and organizations found themselves in a very difficult financial position, and space research became unprofitable. The reorientation and shutdown of specialized plants for space hardware got under way. The ties that were in place are still being severed to this day, and the danger of losing state-of-the-art technologies and a substantial number of highly skilled specialists has not disappeared. All that, plus the hundredfold rise in prices for rocket fuel, electronics, metals, and energy carriers, is leading to the curtailment of space activity in our country. In addition, the scaling down of the armed forces in Russia has resulted in a problem with the personnel who used to support the functioning and maintenance of the ground-based infrastructure used in the civilian space programs.

With the existence of those acute conditions, the government and the Supreme Soviet of Russia have made decisions that are important to the space program. In the law on the budget system of the Russian Federation for 1992 and 1993, spending for the State Space Program was given a separate line for the first time ever, and the average wage in the space industry is to increase in 1993 to the average level for workers of all of Russian industry.

Special agencies for the state management of space activity have been formed in Russia, Ukraine, Belarus, Kazakhstan, and Uzbekistan for the purpose of setting up cooperation and interaction among the space organizations of the countries of the CIS. A legal basis is being created for effecting joint space activity in the CIS countries that is vigorous, mutually beneficial, and equitable. Azerbaijan, Armenia, Belarus, Moldova, Russia, Tajikistan, Turkmenia, Uzbekistan, and Ukraine have all expressed a desire to participate in cooperative interstate space activity.

Finally, the publication of a new concept of state space activity serves as an important landmark in the development of our space program.

In 1992, the Russian Space Agency [RKA] and the Russian Ministry of Defense—along with the Russian Academy of Sciences and the environmental, communications, health care, science, and transportation ministries, as well as other concerned departments—created the **State Space Program for the Period up to the Year 2000**, which defines the chief goals and most important objectives of the space activity of our country. In it, priority is given to projects that facilitate the growth of the space program, introduce leading technologies, and help to solve the most important socioeconomic problems of Russia. The program aims at producing a practical return in such vitally important areas as information transfer, power engineering, ecology, and raw-material resources. It also takes into consideration the country's international obligations.

The first steps in this direction have already been taken. Among the new consumers of space products and services are the Central Bank of Russia, other banks of Russia, and various commercial structures. With the help of Russian commercial organizations, more than 20 space projects involving communications and telecommunications are already under development. Among the clients for those space projects are such large organizations as the Informkosmos Association, the Energiyamarafon Association, the international innovations-related joint venture Koskon, and the joint-stock companies

Global Information Systems, Kuryer [Courier], Gazkom, Sokol, Koss, and Ural-Kosmos. Today, Russian businessmen are already capable of carrying out such complex projects as the 1992 space-vehicle flight called Europe-America 500.

The program calls for considerable money to be spent for applied space operations, military activity, and science-related space research. Let us examine in more detail which of those projects have received the go-ahead and how the face of our country's space program will look by the end of this decade.

Space Communications, Television, and Relay of Information

At present, more than 30 communications satellites, as well as 50 main ground stations and 7,500 auxiliary ground stations for space communications, are in continuous operation in Russia for the direct exchange of international television programs. Nationwide city-to-city communications, as well as high-quality international communications, have been set up across the entirety of the CIS. In addition, our country is leasing satellite-based communications and television channels to a number of foreign countries.

In the near future, plans call for the stage-by-stage organization of communications via satellite with mobile facilities—airplanes, ships, and automobiles—and the offering of the services of satellite-based electronic mail and vehicle-to-vehicle exchange. All of Russia and the CIS will be covered by multiprogram television broadcasting. Plans also call for considerable expansion of the telephone channels for stationary users (so-called fixed communications).

The currently existing system for such communications, Potok-SV, uses Gorizont satellites placed at 10 points in geostationary orbit and the ground stations Azimut, Orbita, Zevs, Nauka, and Pikhta. In addition to providing 2,500 telephone channels, it feeds the first television program to the Moskva network of stations and 3-4 channels of mobile communications. Unfortunately, because the orbital inclination cannot be corrected, the Gorizont satellites, by the end of the third year of their operation, shift 2° in latitude, which exceeds the geostationary-satellite position norms allowed by the International Telecommunications Union, and they must be taken off line immediately.

Plans call for the development and building by 1995 of an upgraded Ekspress satellite operating in the range of 4/6 GHz, with a traffic capacity that is 1.5- to twofold greater and a more advanced system for control and correction of orbit (the program will be implemented by the Russian Space Agency, the Russian Ministry of Communications, and commercial structures). Those satellites will gradually replace the Gorizont vehicles and will occupy three additional backup points in stationary orbit. Also expected is the creation, by 1997, on the basis of that same equipment, of the Ekspress-M satellite, which operates in the 11-14 GHz range, with a traffic capacity four- to fivefold greater than that of the Gorizont satellite. The implementation of that program will reduce the needs for channels of fixed and nationwide communications by fivefold.

For setting up mobile communications (primarily, in the interests of the merchant marine), one channel of the Gorizont satellite relay is now used, which satisfies only 10 percent of the needs for such communications. The Program calls for the creation of a separate communications system, Marafon, on the basis of the geostationary Arkos satellites and the highly elliptical-orbit Mayak satellites. The work will be done in the context of conversion with, by and large, commercial-structure money and the use of well-developed designs. In addition to the highly elliptical-orbit satellites, a system of communications and electronic mail, Gonets, is being developed to set up mobile communications in the 1.5/1.6 GHz and 0.2/0.4 GHz ranges; also under development is the Koskom system, which makes it possible to use middle-orbit satellites to provide direct access to satellite communications channels.

The Ukrainian AssoUniti Association for High-Level Technologies is developing a project for a system of personal communications, Ariadna. The RKA is coordinating that work and the support of efficient use of space-infrastructure hardware and facilities and the allocated radio-engineering resources.

At present, satellite television broadcasting is provided to Russia and the other countries of the CIS by the Ekran system, which is based on two Ekran-M1 spacecraft (in the 0.7 GHz range, the signal goes to a network of simplified receiving stations), as well as by the Potok-SV system, which is based on several Gorizont satellites (the signal is transmitted in the 4 GHz range to a network of Moskva and Orbita stations). Plans call for the creation of the Gals satellites for the transfer of satellite-based television broadcasting in the 12 GHz range, which has been allocated by the world community for those purposes; after Gals will come Gals-R and Gelikon, with the number of TV channels increased to seven from three.

The implementation of the above-enumerated projects will make it possible to solve almost completely the problem of setting up multiprogram zonal television broadcasting for the countries of the CIS and to provide regional television broadcasting in ethnic languages.

The programs involving space-based television broadcasting will be funded by the Russian Ministry of Communications, the RKA, the Ostankino TV and radio company, and commercial structures, with proportionate participation by the CIS states.

Space Systems for Remote Sensing

The hardware projects in this area that are called for by the Program could become the basis for an integrated domestic system for global observation of the environment, natural resource use, and city planning. Unmanned space vehicles in systems of remote sensing

and space-based monitoring are already being used to compile thematic natural-resource maps and to assess hydrological reserves, land conditions, and ice conditions; to perform ecological monitoring of the Earth's surface and atmosphere; to identify areas of the World Ocean that are abundant with fish; and to do much more. Those kinds of information are very promising in commercial terms, too.

For the successful conduct of operations in cartography and in studies of natural resources and the environment—to include requests made by foreign consumers—use of the Resurs-F1 and Resurs-F2 photographic complexes will continue, as will conversion of the Oblik military system to meet national-economy needs. After the Nika-Kuban complex has been built, the effectiveness of photo observation will be raised, with the number of launches cut two- to threefold.

Day-to-day observations of land and sea for purposes of pinpointing pollution sources, monitoring ice conditions, and identifying natural features will be provided by the experimental use of the Resurs-01 and Okean-01 complexes. For purposes of expanding the range of solvable problems and raising the quality of observations, the Okean-0 complex for daily observation of the ocean has been developed and is being built; Okean-0 is now part of the Ukrainian space program. Completion of the building, however, requires that organizational, economic, and technical problems associated with the interaction of the space programs of the CIS countries be solved. Some of the tasks facing that complex could be performed with the gear of the Almaz-1 complex, which is capable of performing daily high-definition, all-weather observation of the Earth's surface. It has been decided to develop complexes for daily observation of land and sea on the basis of competitive projects. The development of the Resurs-02 program has been completed, the complex having an expanded set of onboard gear that enables daily land observation with a resolution of down to 2-5 m (resolution now is about 45 m); the Resurs-Spektr project has also been completed. The Priroda module for the orbital station Mir is being built, as are a number of vehicles that are in the conversion program and are intended for solution of peacetime problems.

Space-Based Meteorology and Environmental Monitoring

The State Space Program of Russia calls for completion of the building of the Planeta two-tiered weather-observation system, which is being developed on the basis of the Meteor-3 space vehicle and the Electro geostationary weather satellite. The work to improve them will continue. Existing and future series-produced and experimental satellites such as Meteor, Elektro, Prognoz, and Oko, which will carry equipment for direct and remote measurements of various parameters of the near-Earth environment, are expected to be used to regulate the monitoring of heliogeophysical parameters and the state of near-Earth space. Some of the measurements will be made with equipment launched into space in the context of conversion programs. Information will be collected, processed, and disseminated by the geophysical services of Roskomgidromet. The successful implementation of the outlined program will improve the efficiency of the use of the Northern Sea Route, reduce spending on the geological study of territories and the inventory of agricultural and farm areas, and make it possible to predict harvests in any region of Russia and the bioproductivity of commercial regions of the ocean and monitor dangerous anthropogenic effects on the living environment.

Space-Based Navigation and Geodesy

Space vehicles that are continuously in the same orbits can provide tens of thousands of ground-based consumers with navigational and geodesic information. Now more than 4,500 ships are equipped with satellite navigation gear that enables them to ascertain their position within 100 m or less. That reduces transportation expenses and increases the safety of travel. From space, highly accurate measurements are made of certain movements of the Earth's crust that have extraordinary significance in the prediction of earthquakes. The international Cospas-Sarsat system ascertains the position of ships, aircraft, and expeditions that are in distress. It has already helped rescue more than 2,500 people. In the near future, satellite navigation systems will service mobile civilian users with a high degree of precision and promptness.

Up to the year 2000, plans call for the use of the dual-purpose space-based navigational-geodesic Glonass complex, which is already deployed in orbit, to provide navigational support of national- economy users and to perform geodesic measurements. When the number of satellites of that system reaches the planned level (36), the system will provide a continuous global "navigation field" of the required accuracy (no less than 100 m for navigation and 15-20 m for geodesy). At the same time, also in use will be the military navigation system Tsikada, which is based on the low-orbit Nadezhda vehicles, which are being upgraded and, in addition to serving the needs of navigation and relaying distress signals (Cospas system), will be used for collecting and relaying auxiliary dispatcher information of the Ministry of the Navy of the Russian Federation (the Kurs system).

Control of transportation systems of a higher class (river vessels, railways, and auto transport) will be done both by a system of personal communications (Gonets, Koskon, and Ariadna satellites) and through the use of high-orbit mobile-communications satellites (the Marafon system) in combination with a ground-based infrastructure that includes a network of reference navigation- communication stations.

Work will continue until the end of the current decade to achieve metric and submetric accuracies in space-based navigational and geodesic systems. That, in turn, will

make it possible to solve a multitude of new national-economy and technical problems. It is entirely possible that the economic impact of that will enable the achievement of cost recovery for coordinate-metric complexes.

All that work will be a part of Russia's Standardized Program for Coordinate-Time Support.

Military Objectives

In the defense area, space hardware will, as before, help to effectively monitor adherence to international agreements, which will make it possible to achieve a standardized information space for all combat arms, and it will occupy a special place in navigation, geodesy, and other areas of support for the armed forces. Worldwide experience shows that, without space-based systems, it is difficult to count on a high level of effectiveness of the modern army. As before, an immense contribution to the support of the space activity of our country will be made by the military-space forces of the Russian Ministry of Defense. They will perform most of the work at the space launch facilities; a number of dual-purpose space systems (i.e., used both for military and for national-economy objectives) will be used as the ground tracking complex.

Science-Related Space Research

This type of space activity enriches us with discoveries and new fundamental knowledge. In earlier years, we gained important data on near-Earth space, on the Moon and the planets, and on the processes that occur in the atmosphere of the Earth and the Sun. Much has changed in our notions of the world around us and about the origin and evolution of the universe.

It would be hard to overemphasize the significance that astrophysical and radiophysical research from space holds for the solution of many fundamental problems of modern science. Instead of just the two small "windows" in the optical and radio ranges accessible to ground-based observation, science now has an opportunity to conduct research across the entire spectrum. The current program for the creation of new science-related space hardware is aimed at obtaining fundamental results in astrophysics, planetology, geophysics, and the study of the Sun and solar- terrestrial relationships. The last area has been given priority, because the results obtained will make it possible to effectively solve a number of applied problems involving the physics of the ionosphere and the biosphere of the Earth. Such projects will include Interbol, Solnechnyy zond [Solar Probe], and Regata [Regatta]. They will be performed with spacecraft of the AUOS family of satellites (developed by NPO Yuzhnoye, in Ukraine), and some unusually interesting science programs have been outlined for them. The Solar Probe, for example, which will execute a flyby of the Sun at the closest possible distance from the standpoint of ballistics, will provide us with unique information about the Sun and the near-Sun environment and will perform gravitational experiments.

Astrophysical research is to be done from aboard the Prognoz-M2 vehicle (in the Relikt-2 project) and the Spektr and Nika-3 vehicles (in experiments involving a study of cosmic rays). The program for the further study of the planets includes the creation in 1994-1996 of the Mars-94/96 and Mars-Aster space vehicles for studying the Red Planet and asteroids from Martian-satellite orbit and with landers. The next stage is expected to deliver Martian soil samples back to Earth.

A program of biomedical research will be performed with the Bion and Nika-B space vehicles, as well as from aboard manned complexes. Much work will be done on the basis of international cooperation.

Manned Flights and Launch Hardware

It is important to note that the Program stipulates the creation of ecologically clean launch systems. In the period up to the year 2000, the Proton and Soyuz launch vehicles will be upgraded. A competition is expected to be conducted very soon for the creation of the mid-class Angara launcher, a standardized series of Dvina upper stages, and small Neva launchers. Work will get under way for the creation of a more advanced heavy launch-vehicle, the Energiya-M, and the development of reusable rocket and aerospace transportation systems (including commercial systems). Particular attention will be devoted to the efficient use of the Russian launch facilities Plesetsk and Kapustin Yar. As before, work will be done that involves servicing and expanding the capabilities of the Baykonur launch facility (in Kazakhstan).

A special place in science-related and applied space research is held by manned missions. Although unmanned vehicles will, as before, be regarded as the main means of studying and using space, the Program calls for maintaining Russia's leadership in long-duration manned missions.

Our orbital stations have been operating successfully in near-Earth orbit for many years. They have been a base for the study of natural resources and mapping of the Earth; study of the atmosphere; and study of physical phenomena and processes that occur in space, astronomical observations, and biomedical research. New onboard systems and instruments have been worked out, experiments have been performed, and industrial operations have been conducted involving space technology and materials science. Essentially, the stations have been integrated science laboratories in which man's participation has expanded considerably the capabilities for conducting research.

In 1993-1995, the Program is to continue the operation of the Mir station, dock two modules to it, and raise its performance specifications to the level planned in its development. That will make it possible to use the station's service life in full, thereby getting maximum return. In 1996-2000, the operation of the Mir-2 station, with a crew of up to nine people, may get under way; the Mir-2 is being developed right now by NPO Energiya on

the basis of the design experience garnered in the construction and operation of the base unit of the Mir station. Mir-2 will be lofted into an orbit with an inclination of 65° (Mir has an inclination of 51.6°), which will expand considerably the possibilities for solving resources-management and ecological problems. Mir-2 will be made up of fundamentally new modules, including a biological module, an engineering module, and an environmental module. The Soyuz-TM transport and the Progress-M cargo resupply craft will be used for the time being in the first stage to provide transportation- and maintenance-related service.

International Space Activity

Ever increasing significance in the field of space activity is attaching to the integration of the efforts of many countries. Such integration enables the most efficient and economically beneficial performance of the most complex, expensive, large-scale space programs. At present, Russia is successfully collaborating with 18 countries in space activity, developing and implementing a variety of projects for various purposes. For example, in the context of an agreement between Russia and the United States, the flight of a Russian cosmonaut aboard the Shuttle is slated for October of this year; and in 1994, an American astronaut will fly aboard the Mir orbital complex. Between now and the year 2000, an additional four French citizens will visit the Mir stations, as will astronauts from the European Space Agency.

Still in the study stage is the project involving the use of the Soyuz spacecraft as a rescue craft for the International Space Station Freedom.

The Program calls for forms of external space activity such as the launch of foreign satellites, the leasing of space hardware, the tracking support of foreign satellites, the exchange of space-derived data, and the provision to foreign parties of the opportunity to receive those data from our space vehicles. Promising space hardware will be developed, manufactured, and perfected in the context of joint projects or individual contracts, and a mutually beneficial exchange of space technologies will be effected. Joint space-based programs are slated in the area of scientific research involving near-Earth space, the Sun, and the planets; in the creation of space-based production of materials, semiconductors, and biopreparations. All that will be of considerable assistance to our space program in this time of limited funding.

Of exceptional importance to Russia's space program is the high- priority area of systems-related, basic, and applied scientific research involving the creation of an advanced scientific-technical and engineering stock of available research. For the first time ever, the funding has been increased substantially for scientific research operations in that area, funding that now stands at about 10 percent of the total amount allocated by the budget for the development of the space program.

Carrying out Russia's new space policy and implementing the State Space Program will enable our country, which built the road into space, to maintain its status as a leading space power and use the space program to renew Russia and make it flourish.

Views on Value of Space Program, Future of Buran

Accomplishments of Space Program Lauded

947Q0073A Moscow KHIMIYA I ZHIZN in Russian No 10, Oct 93 pp 36-39

[Interview with Professor V. P. Senkevich, doctor of technical sciences, vice-president of the K. E. Tsiolkovskiy Academy of Cosmonautics and the Russian Federation of Cosmonautics, and chief of the head department of the Central Scientific Research Institute of Machine Building of the Russian Space Agency, under the rubric "Differing Opinions": "Where Should the Spacecraft Be Sent?"; first two paragraphs are source introduction]

[Text] **These days, even the most deep-seated of principles are being reexamined in every area of life. And that goes for the space program, too—a sector that has always been the most important component of the domestic military-industrial complex. Have the huge sums of money spent for the development and launch of space gear been warranted? Do we need that gear now? In what direction should the space sector in Russia be developed, and should it be developed at all? The articles printed here reflect two substantially different points of view with regard to certain of those problems. And one must believe that there are yet other points of view...**

'The Aim—To Keep the Russian Space Program Intact'

Answering the questions of KHIMIYA I ZHIZN is the vice-president of the K. E. Tsiolkovskiy Academy of Cosmonautics and the Russian Federation of Cosmonautics and chief of the head department of the Central Scientific Research Institute of Machine Building of the Russian Space Agency, Professor V. P. Senkevich, a doctor of technical sciences.

Khimiya i Zhizn: The space program is one of the most expensive areas of human activity. The country has spent vast sums of money on "space" over a period of decades. How efficient and justified can one regard that spending?

Senkevich: First of all, I'd like to say that those sums haven't been as great as one would think. In recent years, the former Union spent about 1 percent of the gross national product on the space program. When you consider that the workers in the sector, along with their families, also make up 1 percent of the country's population, then it turns out that the same amount of money has been spent here, "per capita," as in the country as a

whole. Here are the figures for 1989, a year that can be considered representative because there was none of the current inflation back then: 6.9 billion rubles [R] were spent on the space program; of that, 1.7 billion went for space hardware for the national economy and science, 1.3 billion went for reusable systems, and 3.9 billion went for space-based military information systems. That is much less than the unthinkable losses recorded in many other sectors of our economy. Annual grain losses, for example, were R20 billion that year; meat losses, 6 billion; and above-norm remainders of material values, 247 billion. In that same year, by the way, the United States spent $29.6 billion on space, $22.8 billion of which went for "military" space.

As for efficiency, that's certainly not always measured in rubles. It all depends on what kinds of goals are set for the space program, and those goals have changed more than once over the period of the space program's existence. During the cold war, for example, space-related advances were regarded primarily as the realm of the technical and military-political competition of two systems. That situation existed until the early '70s, when preeminence and prestige both for us and for the United States began, by and large, to retreat into the background. Now the principal criterion is, To what extent does this or that advance satisfy the customer: defense, science, etc. The space race has moved into the realm of technology.

By the way, our space hardware was built with a strictly domestic component and instrument base: the Western countries placed severe restrictions on the transfer to us of any advances that could be used in space or other programs. Nevertheless, our designers have almost always been able to satisfy the requirements of the customers.

Be that as it may, we now have a strong inventory of aerospace hardware. We have broad inventory of launch vehicles capable of lifting 0.5-100 tons; we have built spacecraft for various uses, and orbital stations; and there are in space 160-180 of our spacecraft, linked in some 30 systems. Their operation is supported by a strong ground-based infrastructure—launch facilities, flight control centers, regional centers, and receiving stations for space-derived information.

Unfortunately, the economic difficulties of recent years have also affected the space program. Operational scales in many of its areas have been cut back appreciably. A system of production cooperation decades in the making has been disrupted—a system in which more than a thousand enterprises were directly involved in space activity and more than 2,000 enterprises and organizations throughout the entire former Union were indirectly involved. Spending for the space program in 1991 was cut back by 35%; in early 1992, before the state order was approved, the entire sector was actually frozen, and to pay wages (the average current wage, by the way, is about 1.5-fold lower than the average for all of Russia), almost all the enterprises had to take out loans from commercial banks at enormously high interest rates. Just a little more of this, and Russian will no longer be among the greatest of space powers.

That's why recently we've been thinking seriously about cost recovery of advances and about the possibilities of getting a commercial return for the use of space hardware.

Khimiya i Zhizn: Does that mean that the space program is also entering the age of market relations—with denationalization of property, privatization, and other facets of market economics?

Senkevich: Phrasing the question that way would probably be wrong as it relates to the space program. It would be better to speak of commercialization, that is, about attracting private capital, with state control, to economic activity. That's what has long been done in the leading Western countries—there they strive to comprehensively expand the market for the sales of aerospace industry products and for services based on space systems. But even with that, it's the opinion of foreign experts that a necessary condition for the survival and growth of a space program remains the financial support of its government.

We also see the future of our space program in the joint activity of the state and private capital. True, we still have many unresolved problems here—specifically, there is virtually nothing of the legal basis that is needed. Nevertheless, we can at this point name the principal directions being taken in the commercialization of our space program. They involves things like, for example, the proffering of communications services, the study of natural resources, the monitoring of the environment and weather, the lofting of various kinds of satellites into orbit, and the leasing of space hardware.

Of course, it's still too early to be talking about billions in profits from the space program—right now we have to be talking about, primarily, the cost recovery of individual types of operations and about their commercial prospects. And those prospects will depend on how vigorously and successfully Russia enters the world space market. Right now, more than 130 states are either directly or indirectly participating in it, and that is the criterion by which the overall scientific-technical potential of a country is assessed, and it would be worse for us to fall behind here.

Khimiya i Zhizn: But do we have anything to enter the market with?

Senkevich: According to American experts (and we're generally in agreement with them), Russia has the lead right now in roughly half of the areas involving space hardware. We have today the most powerful rocket with a rather advanced first stage—the Energiya; we have what is for the time being the only orbital station in the world, a unique compact nuclear reactor for use in space, and extremely precise engines for changing the orbit of a space vehicle. The U.S. Department of Defense is very

interested in many of our advances, and they feel that the use of those advances would make it possible to accelerate the implementation of the American SDI program by about five years and save almost $2 billion. In other words, that is the actual value of just those of our advances.

Thus, even the most developed countries are interested in collaboration with Russia in the field of space technologies. But on the other hand, they are, of course, guided primarily by their own interests—political and commercial. The United States, for example, will obviously try to use the situation to purchase more cheaply everything of value that Russia has, in the process getting as far ahead as possible of Japan, Europe, India, and China, but at the same time not allowing the appearance of a serious competitor on the world space market in the person of Russia.

Khimiya i Zhizn: But how about our internal market—will space products or space services appear on it in the foreseeable future?

Senkevich: The space program is itself, above all, a part of the internal market, and it is a big customer for many other sectors. Building space vehicles requires metals, plastics, ceramics, optics, communication systems, power supplies, life-support systems, various kinds of gear, onboard and ground-based computers, and many other things. Of course, part of the budget appropriations earmarked for space goes to pay for all that. In that context, it's very important that the space program, more so than any other sphere of activity (save for the nuclear sector), use the latest scientific and technological advances and thereby serve as a powerful catalyst for progress.

At the same time, the space program this very moment is filling orders from the economy. That involves, primarily, things that have already become customary—space-based communications, television broadcasting, navigation, and monitoring of the Earth's surface for various consumers. In space, we're already producing, on a semiindustrial scale, single crystals, superconducting materials, and ultrapure biomedical preparations. For example, single-crystal cadmium telluride can be used for making x-ray sensors in medical tomographs. As many as a thousand sensors can be made from one crystal 20-25 mm in diameter. On the ground, it is extremely difficult to produce high-quality single crystals; but several kilograms of those kinds of materials have already been brought back to the ground from orbit. By the way, a gram of single-crystal cadmium telluride is worth nearly $1,800 on the world market.

Finally, a third area in which we're active on the internal market, one that is extremely important for the survival of the Russian space program and for the entire economy as well, is the transfer of space technologies to other sectors. For example, the development of the reusable Buran spacecraft and the Energiya launch vehicle involved the development of nearly 500 new designs and more than 100 new materials. Only 20 percent of those advances have a narrow, specialized application; many of the other advances are already being used in the nuclear, aviation, and electronics industries, in the light and chemical industries, in medicine, and so forth.

Khimiya i Zhizn: The representatives of your sector have made those kinds of pronouncements more than once. But I don't recall anything like ever being able to buy anything made with space technology in a hardware store.

Senkevich: Suit yourself, there are plenty of instances like that. Our enterprises and our technologies are used to make refrigerators and cutters, televisions and samovars, juice makers and electric shavers. Our sector is offering the housing construction industry structural and insulation materials, sealants, and so forth. We're offering the power-engineering industry catalysts for removing the flue gases at heat and electric-power plants. We're offering metallurgy various kinds of refractories, and the auto industry, engine valve seats made of aerospace materials (this technology was used to make rocket nozzles). Permanent magnets with high-level magnetic features are making it possible to greatly reduce the sizes of various electric motors, electromechanical converters, and so forth. Articles made of the carbon-carbon composite material argolon are much stronger than the usual graphite materials, and in an aggressive medium they withstand temperatures of up to 500°C and can be used in metallurgy, chemistry, and petrochemistry. The antifriction, self-lubricating material phenan, which is based on porous bronze with special pore-filling polymer additives, remains efficient in aggressive media of up to 600°C and can be successfully used in transportation, in farm machinery, and so forth. And I could go on: I could talk for a very long time on the possibilities for the use of space materials and technologies in the economy. By the way, a special system is being created in our sector now to facilitate that kind of technology transfer.

Khimiya i Zhizn: From the very outset, the space program in our country was under the strict control of party-and-governmental organs in the context of a command-administrative system. What does the structure of the sector and the control of the space program's growth look like these days?

Senkevich: Our space program, in fact, has always featured a high degree of state centralization in its management. But that's typical of the leading Western countries, too. It is only because of the immense concentration of efforts and resources that we have been able to achieve such tremendous advances in going after our main goals.

And those advances would have been even greater if, in approving principal directions to be taken and long-term space programs and plans, the officials at the top had taken full measure of the recommendations of the head institutes and independent experts. What also hindered things considerably were the excessive secretiveness, the

lack of departmental coordination among the consumers and the developers, and the extraordinary monopoly that existed.

Nevertheless, the positive aspects of such an organization of operations managed to predominate. Virtually all the large space projects (with the exception of the mission to the Moon) were completed, although in the process deadlines were not always met and budgets not always adhered to, and the specifications of some items sometimes turned out to be below what was called for. But one mustn't forget that the deadlines were often unnecessarily strict, and the requirements, exaggerated: aerospace systems, especially in the early days, were built at the leading edge of what was technically possible, and no command-administrative measures could have produced better results back then.

As for today, the government of Russia recently made some important decisions aimed at preserving and developing the Russian space program as a sector important to the state. In 1992, the Russian Space Agency was formed, to develop and carry out state policy in the exploration of space and to serve in the role of general buyer of national-economy- and science-related space systems and, with the Ministry of Defense, buyer of dual-purpose systems. The agency has already prepared a draft of the State Space Program for Russia for the Period Leading Up to the Year 2000, the execution of which will preserve Russia's position as a leading space power. The program has gone through interdepartmental appraisal and is being examined in the state commissions and in the government.

Khimiya i Zhizn: What areas in the Russian space program today have been pronounced the most necessary?

Senkevich: The program is based on the need to preserve and develop virtually all the main areas in today's space sector.

In the field of national-economy-related space hardware, that pertains to the setting up of information-dissemination systems (communications and radio and television broadcasting), navigation, environmental monitoring, weather prediction, warning of possible natural disasters, the study of the Earth's natural resources, and, finally, the continuation of work to perfect new space technologies and produce valuable materials in orbit.

Science-related space hardware will be used to conduct further systematic basic research in astrophysics, planetology, geophysics, and other fields of science. Our plans to study Mars and the asteroids are evoking a great deal of interest in the world science community. Most of our science projects will be performed in the context of programs of international cooperation, including commercially based programs.

Space systems will also be used for purposes of defense. The main job here, in accordance with the new defense doctrine of Russia, consists maintaining the strategic stability that exists. In that context, it is important to know that many military space systems, complexes, and means are expected to be used simultaneously for the national economy.

The program-specified operations for insertion systems and reusable systems will be aimed at the technical retooling in that area, one task of which is to preclude the use of toxic fuel components and to give back to the national economy some of the land that was taken out of production before to serve as a drop zone for spent components. The Proton and Soyuz rockets will be updated, and new rockets will be created. Considerable attention will be devoted to choosing efficient configurations of reusable systems and to the completion of the flight tests of the Energiya-Buran system. Russia is performing joint work in the space program with 18 countries. Some of the services involving international programs will be proffered on a commercial basis.

We hope that in the course of this program, our space program will soon assume again a place befitting it and will further benefit hundreds of millions of people.

Superiority of Reusable Aerospace Systems

947Q0073B Moscow KHIMIYA I ZHIZN in Russian No 10, Oct 93 pp 40-43

[Article by A. V. Ptushenko, systems analyst: "Do We Need 'Energiya?'"; first paragraph is source introduction]

[Text] **Systems analyst A. V. Ptushenko, a longtime writer for KHIMIYA I ZHIZN, comments on some of the positions taken with regard to the strategic program for the development of the Russian space program.**

It happens that two schools have long been crystallized in our space program, two approaches to the strategy for its development. One came from Tsiolkovskiy, a confirmed supporter of the "growth" of the space program out of aeronautics; the other got its start in the soil of a new type of armed forces created in the USSR—the Missile Forces (there was never anything like it in any other army in the world—in the United States, for example, missiles were shared by the army, air force, and navy). The first school always dreamed of reusable aerospace systems; the second adhered to the conviction that expendable, purely rocket, vertically launching systems were omnipotent. Supporting each school were prominent authorities, large institutes, large groups of specialists, solid traditions, and strict paradigms.

Of course, both schools were of the same mind about the most important thing: both were convinced that mankind would not survive without cosmonautics. But they are far apart in their interpretation of the main routes to be taken in implementing that imperative. Their views

differ on the priorities associated with this program or that program; on the role of geostationary satellites, which hover motionlessly over a given point on the Earth's surface; on the advisability of forcing a manned mission to Mars and creating a nuclear rocket engine; on the prospects for our country for having reusable aerospace systems and the feasibility of reoutfitting already developed expendable rockets into reusable rockets. It's too bad that V. P. Senkevich, a man I have great respect for, has given, essentially, no attention to these very important problems.

Let's begin with what is perhaps the most pointedly disputed question in today's space program—what to do with the Buran-Energiya system, on which we've already spent, by one set of figures, 16 billion rubles [R] and, by another set, 40 billion. Should we take it all the way, since so much money and labor has already been invested in it, or should we do just the opposite?

In favor of the first solution is a seemingly reasonable consideration: the Americans have developed such a system and are more or less successfully operating it—which means that we need it, too (we used to follow that principle unfailingly). But such an answer seems reasonable only at first glance.

The fact is that we don't have the same geography, the same strategic position that the United States has. From its airbases, it could "get at" the whole of the European part of the former USSR with ordinary frontline aviation; but to do something similar to that, we would need superlong-range aircraft that don't yet exist. That means we have to use space systems in their place, primarily special-purpose space systems. The Americans, who didn't have that kind of problem, could involve themselves in the development of reusable transport systems whose job would be to loft the necessary facilities into the necessary orbits. But for us, that was luxury we couldn't allow ourselves.

Space shuttles—like the Buran-Energiya system—are typical space transportation systems that are partially reusable (the Shuttle more so, Buran less so). But there is one essential difference. Lifting off from the United States, the Shuttle can place a payload of up to 1.5 tons into geostationary orbit; lifting off from our country, it wouldn't be able to loft anything into that orbit!

Our country is located much farther to the north than is the United States—from us to the equator, that is, to the plane in which geostationary orbit lies, is much farther. From the United States, the equator can be reached at an angle of 20-25°; from our country, at an angle of at least 48-50°. Baykonur (which no longer belongs to Russia) is located at 48° latitude; Plesetsk is much farther to the north. But a launched rocket, without additional maneuvers, is capable flying along an orthodromic only—a great circle arc with its center in the center of the Earth—and the angle at which it intersects the equator cannot be less than the latitude of the launch site. In order to swing the rocket into the plane of the equator, several times more fuel is needed at launch from Baykonur than is needed from California or Florida, and its lift capacity simply isn't enough for the payload: after all, all the fuel needed for such a turn is also needed, during insertion into orbit, to initially boost to circular velocity.

Let's continue the comparison of our system with that of the Americans (Figs. 1 and 2) [not reproduced here]. Both have expendable first stages that, after the propellant is expended, are separated and fall to the Earth. When the Shuttle launches from California, its boosters fall into the Pacific Ocean, bothering no one; when it launches from Florida, they fall into the Atlantic (Fig. 3) [not reproduced here]. But with us, the boosters have nowhere to fall: Baykonur is surrounded on all sides by populated areas. All that's left is the desert Chukotka and a few test facilities that have had to be dug out in various places in the former USSR. Because of that, accessible to us—unlike with the United States—are only a narrow range of launch azimuths, which also means an orbit with an inclination of 50-60°.

Even worse is the fact that the orbital airplane Buran has no onboard booster engines. Here's how a launch goes with the Shuttle (Fig. 4) [not reproduced here]: at launch, all the engines are in operation at the same time, including the orbital airplane's engines—they are fed an oxygen-hydrogen fuel from the tank. The solid-propellant boosters of the first stage, after expending their fuel, separate and drop into the ocean (from which they are later removed, put back into shape, and reused); the airplane, with a tank, continues the boost. Not long before the airplane enters the parking orbit, or so-called reference orbit, from which the "orbit-to-orbit towcraft" will start later, its tank, now empty, separates and, along the design trajectory—that is, a precisely determined trajectory—returns to the atmosphere, where it burns up safely; the airplane, by now flying on its own engines, which are fed by onboard fuel reserves, makes its way to reference orbit.

With Buran, however, the picture is completely different. Since it has no booster engine (we simply weren't able to develop a powerful reusable liquid rocket engine), the second stage of the Energiya launch vehicle takes it to reference orbit. And of course, that stage remains in orbit itself. Over time, because of the resistance of the atmosphere—despite the fact that it is extremely rarefied—the velocity of the stage drops, and the stage moves toward Earth. Along an absolutely impossible-to-calculate trajectory: there are too many random factors affecting it. When the second stage enters the dense layers of the atmosphere, some of its burns up; but the engines don't burn up, because they were designed to withstand much higher temperatures. And they fall to the Earth's surface, wherever they please. They weigh, by the way, more than a ton.

One conclusion thrusts itself at us. We need not a Buran with an Energiya, but an aerospace system with a reusable, winged first stage—a booster aircraft outfitted with

jet engines similar to those in regular aircraft. Such a system would be able to make it to the equator, and land wouldn't have to be taken out of production as a drop zone for the first stage, and the second stage wouldn't fall on anybody's head.

Unfortunately, we succeeded in only the theoretical development of such systems (something I also took part in), and gave up in the face of the truly great difficulties associated with building them. But the Americans, who don't need them so badly, are about to pass us up here, too.

But expendable, purely rocket systems, so favored by our "rocket" school, are, in essence, a big waste. I won't risk saying that our rocket builders don't understand that—they understand it, but draw their own conclusions. These days, they see a way out in the appending of reusability to expendable rockets that have already been built, including the Energiya. But the principles of design for reusable spacecraft and expendable spacecraft are, as they say in Odessa, "two big differences." One must pay for reusability with structural weight; but for the rocket, the weight must be as small as possible—otherwise, it simply won't have enough fuel for boost. The reusable spacecraft must use air (as the medium for creating bearing and control forces, as the working fluid of the engine, and as the oxidizer); but for a rocket, the atmosphere is just vexing interference; all its advantages show up in airless space only. So going that route, like trying to cross a chicken with a tiger, is useless.

The Energiya rocket, of course, could be used alone, without the orbital aircraft Buran. Say, for putting large, heavy objects into reference orbit. But all the organic drawbacks of expendable launch vehicles about which we've already spoken would make themselves known in that context.

There's one way out of the impasse: we need to create reusable systems with airplane-like winged first stages.

Some thoughts on other priorities of our space program. These days, we, like the rest of mankind, need to be concerned first of all with solving global problems—energy problems, environmental problems, and many others. Without a space problem, they obviously can't be solved. But for that very reason, many research programs today, including the mission to Mars, can in no way be declared top-priority programs. Life has shown how right the eminent American theoretical engineer K. A. Erike was when he wrote 20 years ago that the priority should belong to exploring near-Earth space in order to replenish the energy and material resources of mankind and to overcome the energy crisis. The essence of the crisis is not simply the lack of energy carriers—oil and coal; it is much more profound and dangerous for mankind. On the surface of the Earth, we can develop energy systems only to a certain extent, in order to avoid overheating the atmosphere. There is only one way to get around that constraint without curtailing the growth of energy consumption—send the energy systems outside the atmosphere. There, the primary energy source would be the Sun. With solar arrays, its radiant energy could be converted into electrical energy, which directional antennas could relay as microwave radiation down to energy receivers located on the Earth's surface. Given certain conditions, that radiation would not interact at all with the atmosphere.

As for the planned revival of operations associated with the creation of nuclear rocket engines, the following can be said. On one hand, those are the only engines that are economical enough, that is, per unit of fuel mass, they can produce enough work for long-duration flights like the flight to Mars. But on the other hand, the same difficulties arise that arise with ground-based nuclear engineering: it's not clear how to ensure safety and what to do with the radioactive waste. And if we're talking about manned vehicles, the problem of a biological shield for them turns out to be virtually insurmountable. And if we say that a mission to Mars shouldn't be considered top priority, then work on a nuclear rocket engine can hardly be said to be urgent.

Of course, in the limited space of a journal, it's impossible to examine all the problems of the domestic space program, however worthy of such they may be. In conclusion, I would like to add just one thing. God save us from converting the space industry into the riveting of pots! Spending on the space program is necessary if we want to save life on Earth. We just have to sensibly and clearly determine what in particular we need to spend the money on. In the opinion of those, like me, who belong to the school of Tsiolkovskiy-Tsander-Erike, the space program represents above all an opportunity to use sources of energy and material that are outside the bounds of Earth. That is what must determine our strategy for the near future.

Excerpt From Report on Buran

947Q0073C Moscow KHIMIYA I ZHIZN in Russian No 10, Oct 93 pp 43-44

[Excerpt from report on Buran issued by commission of experts assembled by the K. E. Tsiolkovskiy Academy of Cosmonautics: "It's Advisable and Beneficial"; first paragraph is source introduction]

[Text] In early 1993, the K. E. Tsiolkovskiy Academy of Cosmonautics conducted an appraisal of the status of the operations involving the reusable Energiya-Buran system. The commission of experts included prominent figures in the domestic space program (including the author of the interview above, V. P. Senkevich). The commission issued a conclusion about the advisable direction of further operations. So that the situation regarding that system is clear to our readers, we are printing here excerpts from the commission's conclusion.

In the early '70s, a fundamentally new space-related situation came about in the world. The United States was developing a reusable space transportation system that would make it possible to increase the flow of payloads into orbit by an order of magnitude and, most important, return from space to the ground heavy space objects... Noted was... a technological breakthrough in strategic arms that, as with the invention in its time of the atomic bomb, upset the strategic balance that had been achieved...

Of course, in the midst of the strategic arms race... the creation of an adequate system was a naturally correct solution... Thus, in light of the situation and the realities that existed in 1976, the decision to create the reusable space system (MKS) Energiya-Buran was a sound and necessary decision...

From the standpoint of today's political situation, the question may arise, did we invest 14.1 billion rubles into that program for nothing?...

The creation of the MKS Energiya-Buran represents the future of the development of space transportation systems, a future development of space and aviation equipment that combines all the leading principles and advances of the space program and aviation. The creation of the Shuttle and the Energiya-Buran was a fundamental breakthrough to new technology... Consequently, the money spent on the creation of the MKS Energiya-Buran was not an unnecessary burden on the budget; it solved a problem important to our country regarding the qualitative and future development of aerospace equipment.

Second, in addition to the future achievements operating for the future of Russia, the creation of the MKS Energiya-Buran makes purely pragmatic sense. Its design-and-technology base makes it possible to create a whole array of promising, ecologically clean, high-level characteristics of launchers...

Third, the use of the new technological solutions obtained in the creation of the MKS Energiya-Buran will have an immediate and direct economic impact in the national economy, the size of which impact is estimated to be 14 billion rubles in the year 2000 (at 1989 prices)...

As can be seen from what has been said, the development of the MKS Energiya-Buran was not only necessary solution, but also very useful solution for the development of the domestic space program and the technological potential of the country...

The reusable space transportation system Energiya-Buran, like the Space Shuttle, represents a first big step that has already been taken in that direction, and it depends on us whether we will go farther... or stop in mid-step because of temporary difficulties and voluntarily, under the pretence of sensible economics, move away from the international aerospace market with a vain hope of returning in better times. With the current rate of development of aerospace equipment, to stop means to fall behind, and fall behind forever...

What should be done further with the MKS Energiya-Buran? Close it down, or finish developing it and begin using it?

At first glance, the simplest and, it would seem, most sensible thing to do from all points of view would be, as some leaders feel, to suspend operations on the system for 8-10 years in the hope that by that time the economy of the country will strengthen and the possibility will arise for financing that expensive program. But one shouldn't be satisfied with the hope for a favorable outcome with such a simple solution. Over that period of time, the entire complex of ground facilities that have been created and the MKS Energiya-Buran itself, including the universal superheavy-lift Energiya launcher, will, in essence, perish physically and become obsolete...

On the other hand, by making the difficult decision to complete the development of the Energiya-Buran system, the Russian Federation is preserving the progressive development of the domestic space program and the high level of scientific-technical potential that propelled it to the leading ranks... And no matter how hard it is to earmark funds for continuing the operations on the creation and use of the MKS Energiya-Buran, it is advisable and beneficial to search them out. Let it be at first a small amount, but enough for this promising area of the space program to get started...

Status of Ukraine's Yevpatoriya Complex in Russia's Spacecraft Control System

947Q0074 Moscow NOVAYA YEZHEDNEVNAYA GAZETA in Russian 20 Jan 94 p 1

[Article by Oleg Volkov, under the rubric "Details": "Ukrainian Rocket Builders Are Trying To Steal Into Russian Space"]

[Text] Hardly had Russia sort of smoothed out some of its space business with Kazakhstan when it "ran into snags" with another situation—this time with Ukraine. On 10 January, after a year-and-a-half silence, the separate tracking complex in Yevpatoriya, after connecting with the orbital station Mir, was "showing off" in the cosmic ether. Of course, Ukraine's attempt—the first in the history of the planet in which one state controls the space vehicle of another state—wasn't without excesses. True enough, the people in orbit didn't notice that: knowledgeable staffers from the Flight Control Center near Moscow assure us that the contingency situation that arose when the Soyuz craft was docking with the station, for which some mass media have already blamed Ukraine, was caused by other circumstances. But then, on the ground, many have responded overly sensitively to the signals from Yevpatoriya.

The fact of the matter is that a year and a h. lf ago, all three tracking complexes located in Ukrainian territory (in Simferopol, Yevpatoriya, and Dunayevtsy in Khmelnitskaya Oblast) were disengaged from the unified Russian loop for controlling space vehicles. And, as we are told by the press service of the Military Space Forces of the Russian Federation Ministry of Defense, that step was absolutely necessary and justified for the interests of the Russian state. Ukraine, which at the time was going through the very peak of the self-effusive boom, nationalized the complexes and flatly refused to resubordinate the military servicing them to the Russian command. But that is a necessary condition for the normal functioning of orbital complexes and vehicles—hardware, as we know, has nothing to do with democracy or pluralism.

So in 1992, with one stroke of the pen, three complexes stuffed with super electronics and other "high-tech" gear were buried—in a very literal sense, the not-very-sweet fate of the scrap yard was prepared for their remains. According to data from the Russia's Military Space Forces, nearly a third of the military servicemen were immediately placed on reserve status, 30 percent agreed to give up their warm and cozy southern nests for the prospect of work and were transferred to Russia, and the rest declared their oath of allegiance to Ukraine. What they did until 10 January, no one knows—since, as our military people assure us, it is virtually impossible to operate the complexes "for what they're supposed to do" in unmanned mode.

The only exception was the Yevpatoriya Center for Deep Space Communications, which was operating as before "in the system." In theory, substitutes were found in Russia for all three Ukrainian tracking complexes—not full-fledged substitutes, of course, but substitutes that were entirely satisfactory. And only the Yevpatoriya center, with its 70-meter antenna (a second complex, and the only one in Russia, with similar capabilities is located near the Far East's Ussuriysk) couldn't be totally eliminated from the plans. Yevpatoriya figures in the agreement on the international space observatory Granat, which was concluded in 1988, when parties of the Belovezh agreement hadn't yet become political diehards. Violation of the conditions of the hard-currency agreement would have threatened Russia with rather large fines, and so, as happens in such cases, the question was solved very quickly and, without any problems on the Ukrainian side, agreed to.

But nobody made any agreements on the control of Russian space vehicles from within Ukrainian territory!

True, in the space circles people have long been talking as if Ukraine was ready to return to the unified control loop. In the Russian Space Agency, they assert that the problem is being studied—in fact, nobody wants the unique equipment that, by the way, was created by the entire country (USSR) to get lost. And preliminary agreements already exist.

But Russian Space Agency officials refuse for now to answer the question about who it was "on our side" who sanctioned the initiative regarding the separate tracking station in Yevpatoriya. In an interview with IZVESTIYA, the director of the tracking complex, Col Viktor Dubasov, declared that those under him are simply voluntarily backing up the work of their Russian colleagues. At the same time, however, it is obvious that such decisions are not being made by the officers of the middle ranks.

In any case, all the talks are being conducted behind the backs of those who are directly involved in the control of Russian space hardware. For the Military Space Forces that are responsible for both military orbital equipment and all the "civilian" equipment, the "revival" of Yevpatoriya was a big, and not very pleasant, surprise. The commander of the Military Space Forces, Col Gen Vladimir Ivanov, who is also the chairman of the Interstate Commission on Manned Missions, came out against the initiative. The Russian military feel that all the attempts of Ukraine to return to the "loop" will be feasible only after the problem of the division of the juridical responsibility is solved and a bilateral agreement regulating the activity of the Ukrainian space forces is signed. And until then, any inclusion of Yevpatoriya is just senseless: the Ukrainians will not be able to control space vehicles without knowing the highly classified system of codes, but to create rather serious hindrances will be simple.

Pros and Cons of Cooperation on Alpha Space Station Project

947Q0075 Moscow NEZAVISIMAYA GAZETA in Russian 27 Jan 94 p 6

[Article by Lev Kamanin, under the rubric "Opinion": "The Space Joint Enterprise 'Alpha': Will It Happen or Not? Recent Rivals Are Interested in Collaboration in Orbit"; first two paragraphs are source introduction]

[Text] According to the predictions of futurologists, a cherished dream of mankind will be fulfilled in 2017—the flight of an international crew to Mars that will put researchers on the planet's surface. The choice of that year for the Mars mission was, of course, no accident: that's the year of the next occurrence of the closest approach of the blue and red planets, during which their orbits will closest to each other. But even with the most favorable conditions for the mission, the flight to Mars and back to Earth will take about two years.

The only way to prepare the cosmonauts for such a journey and to be make certain that the life-support systems are reliable under conditions of long-term weightlessness is aboard a long-duration orbital station.

Two Tactics

After the successful completion in the summer of 1975 of the experiment in the Soyuz-Apollo program, the American astronauts didn't go into space for almost six years.

Regular space missions were resumed in the United States in April 1981, aboard the Space Shuttle orbital airplane.

Without their own long-duration orbital station, the Americans were forced to be content with short-term "runs" into near-Earth space. The U.S. tactic for exploring near-space was the opposite of ours, which consisted of long-term missions (up to a year or more) aboard the Salyut and Mir stations. True enough, about 10 years ago, an ambitious program for the creation of the international Freedom orbital station under the aegis of the United States appeared, but it was not judged to be implementable because of, first, the considerably higher cost of the Shuttle flights (by comparison with the cost of the project itself) and, second, the amplification of the confrontation between two superpowers in a cold war. The latter factor played a decisive role in the fate of the Freedom station.

The fact is that at roughly that time, in response to the placement of Soviet missiles in countries of Eastern Europe, the U.S. government officially announced the adoption of the doctrine of SDI, the Strategic Defense Initiative, which aimed at developing protective laser armaments and placing them in space. Was the doctrine of "star wars" a flat-out bluff by the Pentagon? Military specialists still have to puzzle that out (reports have already appeared in the press about the falsification of results of supposedly successful tests involving the detection and interception of ballistic missiles by SDI systems). At any rate, even the powerful aerospace complex of the United States turned out to be incapable of simultaneously conducting work on the expensive SDI programs and Freedom—and the preference was given to the former.

The Death of the 'Star Wars' Doctrine

The intention of the United States to carry out the SDI program was taken at face value by the Soviet leadership. Mikhail Gorbachev declared more than once at strategic arms limitations talks that the response to the placement of SDI systems in space would be an "unsymmetrical decision." And he kept his word. Hardly had the Americans managed to make sense of the results of the first tests in the SDI program, when, in something like two or three years, one of the contending superpowers collapsed.

After that turn of events, the doctrine of "star wars" entered a phase of rapid withering. It couldn't be saved even by the extravagant announcement of our postcommunist leader about the readiness of Russia to take part in the further development of SDI, aimed now at either protecting against an attack by some third country or averting alien invasions predicted by astrologers or collisions between the Earth and asteroids.

International Project

Be that as it may, the Americans, after abandoning SDI, now had the opportunity to devote themselves to the Freedom station. As a result of the strict budget policy of Congress, which had cut back the annual appropriations for the Freedom program to $2.1 billion, NASA had to rework the design of the station substantially in order to reduce its size and cost.

But at that time, rumors were afoot that Russia, which had become the successor to the Soviet Union, was getting ready to sell the existing Mir orbital complex. When those rumors couldn't be confirmed (who, after all, needs a station with only two or three years of service life left?), the U.S. administration strengthened its idea of building a long-duration orbital facility with the help of a number of Western European countries, as well as Japan and Canada. Soon after that, Russia, too, came to be regarded as a potential partner, and by as early as the summer of 1993, a fundamental agreement was reached between NASA and the Russian Space Agency (RKA) on the use of units of the Mir-2 orbital complex designed at NPO Energiya and a modified Soyuz spacecraft.

As a result of subsequent talks, including talks at the governmental level, a version coordinated as of December 1993 was adopted for the international station Alpha, half of which consisted of Mir-2 modules. The other half of the long-duration Alpha station was to be represented by the laboratory and living compartment of the United States, the European and Japanese laboratories, and the Canadian module of service systems. Construction of the station in three stages is called for, with completion of the full-scale assembly in 2003, with a service life of 10-15 years.

In Bed With the Russian Bear?

It would seem that one could only welcome the agreement achieved as an important step on the path to expanding international cooperation in space research. In point of fact, however, the prospects for the practical realization of the Alpha project are far from rosy.

First, still unresolved in the very important question of the status of the joint enterprise created in orbit—things like the composition of and replacement schedules for the crews and the procedures for the use of experimental results by the partners. The European participants in the international project, unhappy about the fact that, for some reason, they were not invited to the negotiating table, have already expressed their own fears about being second-string partners because of the "extraordinary activity of the Russians." The European Space Agency is concerned about the fate of the Columbus module (which costs $1.5 billion), which is being developed by Europe for the Freedom station and which may turn out to be superfluous in the event of a further transformation of the long-duration orbital facility project. Also showing dismay are the Japanese—the developers of an experimental module whose cost is estimated at $662 million.

Second, in the United States itself, the reaction to the Alpha project is not at all unified. If the president's team is unconditionally in support of the new design, a number of senators and a large group of representatives

are assuming the role of ardent opponents to it. The debates in the Senate are particularly pointed. As reported in the weekly AVIATION WEEK AND AEROSPACE TECHNOLOGY, one influential congressman even found it conceivable to go to Sen. Barbara Mikulski, who is responsible for NASA funding, with the clearly ungentlemanly question, "Is the honorable madam chairman still really attracted to the idea of getting in bed with the Russian bear?"

Birthday Gift

According to preliminary estimates by NASA specialists, the total spending by the United States for building the Alpha station will be $19.4 billion—$4.7 billion less than the original Freedom project. Despite such substantial savings, a group of representatives sent Vice-President Gore a note in which they unanimously announced that "Congress will insist that the United States is capable of building and putting on line its own station, without anybody's help and at any time."

At the same time, however, supporters of the Alpha project feel that Russia, like the other partners in the international collaboration, should not require a cent of compensation for providing the Mir-2 modules, which will make it possible to build the long-duration orbital facility cheaper and two years faster. Russian specialists used to try to address the compensation issue, basing such compensation on the fact that, thanks to Russia's participation in the project, the United States will save $7 billion—$4 billion as a result of the use of the Mir-2 modules, which are modified units of the tried and proven Mir complex, and $3 billion as a result of the reduction in the number of Shuttle flights needed. The White House administration and the NASA leadership, however, have wisely distanced themselves from the "inappropriate" claims of the Russian side.

Acting on the principle "not being too pushy," RKA director Yuriy Koptev, in an unofficial conversation with NASA director Daniel Goldin, announced that Russian is, as it were, in agreement with the "free partnership" for the realization of the joint project. That's why the appropriation of $400 million to the Russian side in the context of the contract concluded during the U.S. vice-president's December visit to Moscow can be regarded as nothing other than a birthday present. The hope is that that money, intended for supporting joint operations during the period of 1994-1997—that is, in the first, or preparatory, stage of the Alpha program—will help to keep our space program afloat, that is, will preserve a considerable number of jobs at aerospace enterprises.

Caution

The U.S. congressmen who are against the Alpha project cite as their concern the political instability both in Russia itself and in a number of CIS countries. The disheartening results of the elections for the new Russian parliament are being used by them as just one more ponderous argument in support of their negative attitudes. And then there's the recent political maneuver by Kazakhstan, which required $7 billion a year in rent for the Baykonur launch facility, which was built with the money of the taxpayers of the entire Soviet Union, and five million hectares of desert allocated for military testing grounds.

So one can understand the caution with which the U.S. and Western European community relate to Russia as a partner in all spheres of joint activity, including space activity.

Nuclear Power Sources for Space, Cooperation With U.S.

947Q0081 Moscow KOMMERSANT DAILY in Russian 29 Jan 94 p 8

[Article by Sergey Morgachev, Vladislav Golubev, under the rubric "Market of Nuclear Technologies": "U.S. and Russia Combine Forces in Space Power Engineering"; first paragraph is source introduction]

[Text] Specialists are combining the near future of space hardware and the use of nuclear power units and propulsion systems. The first such units have already been developed and are "aloft," and the second generation is under development. That field is one of the fields in which Russian firms still have undisputed preeminence, which has enabled them to enter the American market with their advances and begin collaboration with American science centers and firms. The vice-president of the science center Kurchatov Institute, Academician Nikolay Ponomarev-Stepnoy, who just returned this week from the United States, told KOMMERSANT DAILY that President Clinton's administration continues to support that collaboration. Commenting here on the situation is KOMMERSANT DAILY reviewer Sergey Morgachev and expert Vladislav Golubev.

Technology

Of the two types of space nuclear power unit under study since the 1960s (see the sidebar at end of article), specialists (both Russian and U.S.) now prefer small nuclear reactors. Russian firms that have been on that road from the very beginning have, at this point, achieved a 10-year lead over their American competitors, who have been investing their money primarily in work involving radioisotope generators.

Back in the times of the USSR, two groups of developers of space nuclear reactors came about in Russia, and they developed two models—the Topaz and the Yenisey (which is now depicted in the external market as the Topaz-2). Those units are roughly equivalent in their main parameters, although they have certain design features that differ. There are no American or other foreign units like them.

Topaz: designed by the state enterprise Krasnaya Zvezda (in Moscow); conceptual work and some tests performed

by the Physics and Power Engineering Institute (in Obninsk). Yenisey: designed by the Central Design Bureau of Machine Building (in St. Petersburg); conceptual work and some tests performed by the Russian science center Kurchatov Institute. The NPO Luch (in Podolsk), which is involved in fuel cells, is participating in the work being done by both groups.

It's natural that those two groups of companies are competitors—only the Topazes have gone aloft into space up to this point (in 1987 and 1988), as have the Krasnaya Zvezda units that preceded them. But the collaboration with the United States, which has already produced commercial results, has so far centered on the Yenisey. At the same time, there is also interaction between the two "teams." At present, studies of the new models of the nuclear units are being done jointly.

Russian firms also enjoy a large advantage in work being done in the field of nuclear engines for space vehicles. That work, which was being done intensely in the USSR in the '60s and '70s, is continuing now, albeit on a much smaller scale. Low-thrust jet engines, which can be used for maneuvering vehicles in orbit, already exist in actuality in the form of experimental models.

Russian organizations now involved (or once involved) in the field of nuclear engines for space vehicles: the science center Kurchatov Institute (Moscow), NPO Energiya (Kaliningrad), Scientific Research Institute of Thermal Processes (Moscow), the Design Bureau of Chemical Machine Building (Voronezh), the Physics and Power Engineering Institute (Obninsk), NPO Luch (Podolsk), the Scientific Research Design Institute of Power Engineering (Moscow). Some of the work has been done at the Semipalatinsk testing grounds (Combined expedition of NPO Luch, the Scientific Research Institute of Thermal Processes, and the Kurchatov Institute); at present, the status of the facilities at the testing grounds is the subject of talks between Russia and Kazakhstan.

Commerce

The good sense of a collaboration with the United States on nuclear power units and nuclear engines for space is evident. For the Russian firms, it represents the receipt of the first tens of millions of dollars and the prospect of larger contracts. For the American agencies, it represents an opportunity to cut spending on military and civilian space programs (the program under discussion now for the creation of a new nuclear reactor could cost nearly $1 billion; the program associated with a mission to Mars, $200 billion). For American firms, it represents an opportunity to reduce the costs of operations, which would enable them to "breach" their government funding. There's also interest on the part of potential commercial users of nuclear energy sources for space (the Motorola company).

The U.S. administration, which is treating space programs with a good deal of reserve, has still not made a decision about the full-scale funding of the program for the nuclear power unit, and certainly not about the Mars program or the nuclear engines for it—even though in NASA circles and American aerospace firms right now, people are trying to move the idea of a mission to Mars, which only recently was considered totally science fiction, to a practical plane. At the same time, however, a number of companies (such as Space Power, Rockwell International, General Atomic, Aeroget, General Electric, Westinghouse, Grumman, Thermo Electron, Rasor Associates, Teledyne, TRW, Martin Marietta, and POD Associates) are conducting research in both areas.

Russian firms are being brought in on the work on nuclear power units through the firm International Energy Technologies (INERTEC).

The INERTEC company was set up, on the Russian side, by the science center Kurchatov Institute (Moscow), the Central Design Bureau of Machine Building (St. Petersburg), NPO Luch (Podolsk), and the Scientific Research Institute of Thermal Processes (Moscow) and, on the U.S. side, by the International Scientific Products (ISP) firm. In turn, ISP was created by four American science centers (including the well-known Los Alamos Labs and Phillips).

At present, several contracts exist between the Russian firms and ISP. In the context of one of them, two Yenisey (Topaz-2) reactors are at a laboratory center of Phillips, where ISP specialists are conducting stand tests of them. The units were delivered to the United States without a fuel charge, for temporary use and on the condition that the right of property belongs to the Russian firms, with no transfer to the United States of technology or right to open the units. According to that contract, the Russian firms received $13 million (funding was by the U.S. Department of Defense); under discussion is the delivery for temporary use of four more units, which could bring in an additional $20 million (the customer could be a different agency). In another contract, several series of tests are being conducted on a stand belonging to the Institute of Nuclear Reactors of the Kurchatov Institute center. The final point of that stage consists of flight tests of the Yenisey and several maneuvering engines—including those developed by the Scientific Research Institute of Thermal Processes and the Kurchatov Institute—on an experimental satellite that is to be launched some time in 1995-1996.

Launches of Space Vehicles With Nuclear Power-Supply Units

Country	Number of launches	Year of last launch
Radioisotope generators		
USSR-Russia	4	1969
U.S.	22	1977
Nuclear reactors		
USSR-Russia	35	1988
U.S.	1	1965

If things get as far as the opening in the United States of a full-scale program on a nuclear power unit, the Russian contracting parties have some big opportunities to take

part in that program, and the amount covered by the contracts could be on the order of as much as $100 million. At present, in yet another contract, Russian firms that are members of INERTEC are participating in preliminary studies of a reactor of higher power (see the table below).

Nuclear Reactor Units for Space Vehicles

Project/model name	Type	Country	Key firms/organizations	Electrical power, kW	Service life
Projects realized					
Topaz	Thermionic	Russia	Krasnaya Zvezda State Enterprise (Moscow), Physics and Power Engineering Institute (Obninsk)	6	3
Yenisey	Thermionic	Russia	Central Design Bureau of Machine Building (St. Petersburg), Russian Science Center Kurchatov Institute	6	3
Typical projects of the '90s					
SNAP-TOPAZ	Thermionic	U.S.-Russia	International Energy Technologies	30-40	5-7
Unnamed	Thermionic	Russia	Krasnaya Zvezda State Enterprise (Moscow), Central Design Bureau of Machine Building (St. Petersburg), Russian Science Center Kurchatov Institute (Moscow), Physics and Power Engineering Institute (Obninsk)	25-30	5-7
SNAP-DYN	Brayton cycle	U.S.	Rockwell International	50-60	10
RP-100	Thermionic	Russia	Russian Science Center Kurchatov Institute (Moscow), Physics and Power Engineering Institute (Obninsk), Krasnaya Zvezda State Enterprise (Moscow), Central Design Bureau of Machine Building (St. Petersburg)	100	10
SP-100	Thermoelectric	U.S.	Jet Propulsion Lab, Los Alamos Lab, General Electric	100	7-12

Joint work—although on a very small scale for now—has begun on nuclear sustainer engines: the Kurchatov Institute is collaborating in that area with Rockwell International and Aeroget.

[Sidebar]

- Nuclear power-supply units for space vehicles are either radioisotope generators or small nuclear reactors. Work on them and other units began in the USSR and the United States in the '60s. The first such units had a very low limit of the power that was actually achievable (on the order of 5 kW), which is why at present the key direction being taken is the "reactor" direction. Units that produce 6 kW have already been developed, and research is under way to develop new units that produce as much as 100 kW. At 25 kW and above, reactor units have an advantage over all other energy sources in a key area—ratio of power to mass, with a very large service life (the duration of operation). Nuclear reactors are especially effective for orbital vehicles with large energy requirements and for nonorbital flight.
- Nuclear engines for space vehicles have been under development in Russia and the United States since the '60s, but the work was gradually cut back in connection with the successful development of chemical engines. Both in Russia and in the United States, there are experimental models of orbital maneuvering engines in which nuclear energy is converted into electrical energy for ionization, heat up, and acceleration of the working medium. The concepts of a nuclear "sustainer" engine with direct heat up of the working medium in the reactor or with conversion of the energy to electrical energy are being studied. It is felt that for use in interplanetary flight—to Mars, for example—engine power will have to be 10-100 MW.

Prospects for Russian SLV Industry

947Q0082 Moscow ROSSIYSKIYE VESTI in Russian 1 Feb 94 p 5

[Article by Dmitriy Payson, under the rubric "Space": "What Will We Be Flying On?"]

[Text] If Russia is not the homeland of elephants, it's at least the homeland of the most inexpensive and reliable launch vehicles in the world.

In the past, that has made it possible to save substantially on the development of satellites that are more advanced, primarily photoreconnaissance satellites. If the Americans spent more than $100 million on launching a heavy "spy," the heaviest Soviet launch vehicle, Proton, cost 40 million. In addition, recon satellites themselves were initially created on the basis of the Gagarin Vostok, were placed in orbit by the medium R-7 Vostok rocket, were manufactured at a plant in series production, and were very inexpensive. They were launched and forgotten, as it were. Within a week or so, you get a capsule with photographic film. All the enemy's intrigues as if they were on the palm of your hand.

The R-7 rocket, the "Golden No. 7," was developed by the Podlipkinsk-based OKB-1 [Special Design Bureau-1] under the guidance of S. P. Korolev and V. P. Mishin. That's where they started working on the modest Zenits. In 1963, domestic, series-produced, first-generation reconnaissance satellites went on line. And then No. 7 and the Zenits and some other things were transferred to the Kuybyshev branch of OKB-1. Now it's the Samara-based Central Specialized Design Bureau.

Academician D. I. Kozlov heads it.

Beginning in 1957, various versions of the R-7 rocket lifted off from Baykonur and Plesetsk and placed all the Vostoks and Soyuzes and a good many Kosmoses—peaceful as well as not so peaceful—into orbit. But time passed, and eventually seven tons, the maximum lifting capacity of that rocket, wasn't enough for the developers of space vehicles. But the 20 tons of the Proton was a bit too much. In the mid-1970's, specialists from the Moscow Central Scientific Research Institute of Machine Building, apparently not wanting to part with the traditional No. 7's, put out the first rough sketches of the 77 rocket. Then that rocket became the well known Zenit. It could lift as much as 13 tons into orbit and was manufactured in Dnepropetrovsk at NPO Yuzhnoye. So it was a domestic rocket, and became exported. But the needs for lifting heavy payloads remained.

At the present moment, the Central Specialized Design Bureau is working on the project for the Rus launch vehicle. It expects to use some of the elements of Zenit, primarily the control system, to substantially improve the characteristics of the veteran R-7 rocket, as well as increase the payload by half a ton.

On the other hand, special requirements are being placed now on rockets in terms of ecology. So the R-7 is running on trivial kerosene and entirely safe oxygen, and, except for the mass of scrap in the drop zone for spent stages, it's not doing any particular harm to the environment. But the heavy Proton, as it slams into the ground, sprays around itself what is left of the unburned fuel—nitrogen tetroxide and unsymmetrical dimethylhydrazine (correctly pronouncing those names is one of the principal habits of student rocket builders). Those horrible reddish-yellow chemicals do have one nice feature: their maximum allowable concentration in air is below the level of sensitivity. Roughly speaking, when a human finds himself in a nitrogen tetroxide-UDMH environment, he at first gasps for air and then begins to feel as if something doesn't smell right. That's why the Proton developers—the staffers at the Khrunichev State Rocket-Space Center—are making improvements on it at present. Before the end of this century, plans are to use the Proton M—instead of the 21 tons of cargo, it will be able to delivery as much as 22.3 tons into low near-Earth orbit. But the main thing is that the new control system will make it possible to substantially reduce the drop zone for spent stages and to place them with almost "jeweler's precision." A special system will make it possible to combust the unused portions of fuel before the rocket falls to the ground.

But that's all housekeeping business. On the world market, Lockheed-Khrunichev-Energiya International is representing the interests of the Proton developers. Whether M. Khrunichev, the people's commissar for the aviation industry, would have ever thought or guessed what loud company he would fall into, no one knows. But the company is not without success in moving the Protons to market. In late 1995, that rocket will place a communications satellite manufactured by the Space Systems/Loral firm into orbit; talks are also under way about the launch of four additional vehicles.

Things are relatively easy for Proton—there aren't that many rockets of that class in the world, and our "heavy lifter" faces competition from only perhaps the American Titan. But competing with the R-7 are the Ariane of the European Space Agency and a number of American mid-class rockets that are currently in use or are expected to be used. It would seem that everything is leading up to a real "cold war" breaking out in the space market at the turn of the century. But then...

"Main European Rocket Firm About to Sign Agreement on Cooperation With Russian Rocket Builders!" is the kind of sensationalist headline that appeared in newspapers at the end of October. As it turns out, representatives of the Central Specialized Design Bureau and the Paris-based Aerospatiale, purposely not informing the public, are almost ready to sign the unprecedented contract.

The firms are getting ready to develop a launch vehicle by 1996. The first stage is expected to be the first stage of the Samara Vostok; the Parisians will build the upper stage. As it is, the contract is not signed yet, but, in the words of the representatives of the two sides, recent

difficulties have been overcome. "On the path to this program," declared Central Specialized Design Bureau Deputy General Designer G. Fomin, "there are no technical or any other obstacles." And he promised that he would launch a rocket from Plesetsk in 1996. And Vladimir Saygak, a Samara specialist in outside communications, praised the Moscow officials—there are no impediments on the path of the new rocket. And the events of early October? "It took place in Moscow, not in Russia."

It seems that the good old No. 7 will still be in service. Especially since the now foreign Zenit rocket is now handcuffed with large and small problems. On 4 October 1990, the 15th in the Zenit series blew up on the launch structure, eliminating one of Baykonur's pads. As it turns out, one of the sustainer engines broke down. Although launches have resumed since then, the pad is in ruins. The most recent Zenit lifted off on 16 September 1993.

In December, the deputy general designer of Dnepropetrovsk's Yuzhnoye Design Bureau, Yu. Smetanin, said that his firm has orders to fill from the Russian government until 1995—at 3-5 rockets a year; after that, it's hard to say. Yuriy Smetanin complained about the politicians—and the Russians are complaining about the Dnepropetrovskians, who are striving to convert their relationships with domestic buyers to a dollar basis.

Again those dollars! We would hope that the Rus project will hold up no matter what and that the Russian space program will not be left with no reliable "cabs." Otherwise, things will be bad. After all, for recent launches to Mir, the launcher had to be taken from the arsenal of the space forces—there weren't any others. And the arsenals of the space forces aren't made out of rubber.

Government To Hold Controlling Interest in Privatized NPO Energiya

947Q0086 Moscow KOMMERSANT DAILY in Russian 8 Feb 94 p 1

[Article by Nikolay Podlipskiy, under the rubric "Privatization of the Space Sector": "More Than Half of 'Energiya' Will Remain With the State"; first paragraph is source introduction]

[Text] **The privatization of the enterprises of the military-industrial complex and especially of Russian rocket-and-space firms has long been the arena for the most heated discussions between supporters of the activation of the process and opponents. The almost legendary technological dissociation of those production areas from the rest of the national machine-building complex has already stirred increased interest toward the sector among outside investors. That same attractiveness, however, is serving as sufficient justification for sector officials to shield the enterprises from voucher privatization, i.e., privatization that is actually free. In that vein, the presidential ukase that was issued this past weekend on the privatization of NPO Energiya was, in essence, an *ultima ratio* denationalization of the military-industrial complex—the inability to totally block the process of privatization is compensated for by reserving as federal property the controlling bloc of shares.**

One could say that the scientific-production association [NPO] Energiya is the best-known space firm in the world—before the other "mailboxes" of the sector were declassified, it was that enterprise that was synonymous with the Soviet space program overall. In addition, all the contracts for the flights of Western specialists to the Soviet (now Russian) orbital stations Salyut and Mir were concluded with that NPO. The special status held by Energiya in the Russian space industry enabled enterprise officials to have a relationship special to them—in November 1992, a draft of a governmental decree on the privatization of the NPO was sent to Goskomimushchestvo, and in January of last year, Viktor Chernomyrdin signed that decree. The document called for the organization of a new joint-stock company in the form of a holding company that would be made up of the head design bureau (in Kaliningrad), the experimental machine-building plant (in Kaliningrad), and the Volga and Primorsk affiliates (in Samara and the city of Primorsk, Leningrad Oblast). Preliminary estimates put the authorized capital for the holding company at about 1 billion rubles [R].

But it's obvious that the government couldn't set the leading enterprise of the sector "free" completely—Energiya plays a key role in the manned space program. Ironically enough, complete denationalization of the enterprise wouldn't suit Russia's Western partners, either—especially NASA. In the fall of last year, at a meeting between the first vice-premier Oleg Soskovets and the leadership of that organization, the representatives of the American side complained about the lack of coordination between the positions of the government and the NPO in terms of collaboration on the development of the orbital station Alpha. Oleg Soskovets promised to "settle" that problem.

Thus, the presidential ukase that came out yesterday buried, once and for all, the initial hopes of NPO officials that they would be able to "buy back" from the government 26 percent of the shares of the mother company—for three years, secured as federal property are 51 percent of the shares of the S. P. Korolev Russian Space Corporation Energiya (that's the full official name of the enterprise). But privatization of Energiya (which is due exclusively to the persistence of its leadership) could be virtually the only exception in the entire trend associated with the setting up of Russia's rocket-and-space complex—a more popular idea in the government is to create, at the leading enterprises of the sector, federal space centers that would be completely under the control of the state and could not be privatized (at least, for vouchers). [Box]

Sphere of Activity of the Russian Space Corporation Energiya:

- Creation and operation of an orbital complex consisting of the permanently manned Mir station and the transport craft Soyuz-TM and Progress M
- Creation of the reusable space transportation system Energiya-Buran (operation of the system has been mothballed)
- Creation of "orbital towcraft"—upper stages for launchers (units D and DM)
- Production of household goods, plus prostheses for the disabled

Baykonur Impasse May Force Russian Consideration of New Cosmodrome

947Q0085A Moscow SEGODNYA in Russian 10 Feb 94 p 9

[Article by Veronika Romanenkova and Semen Ivanov: "Kazakhstan in No Hurry To Solve Baykonur Problem. Russia Has Seriously Thought of Constructing Its Own Spaceport"]

[Text] It is probable that Kazakhstan, which a little more than a month ago signed a memorandum on the status of the Baykonur cosmodrome, has decided if not to reexamine its position, in any case to stall the adoption of the conditions for use of the cosmodrome. The recent negotiations of Russian and Kazakh experts did not yield virtually any results. The Kazakh side criticized the proposals formulated by the Russian representatives, but did not make their own counterproposals, other than the resurfacing idea of transformation of Baykonur into an international space company.

A visit of Nursultan Nazarbayev, president of Kazakhstan, to the United States will begin on 14 February. It is proposed that an agreement be concluded on cooperation, including in the space research field. The Kazakh leader is attempting to clarify whether the United States intends to participate in Baykonur becoming a joint-stock company. The experts do not anticipate great enthusiasm on the part of the Americans because the appropriations for space research have recently been cut back greatly.

According to the plan of the president of Kazakhstan, the cosmodrome will become a joint-stock company of the open type, with the stockholders being Russia, Kazakhstan, Ukraine and other countries who so desire. However, at Baykonur there would be no place for Russian soldiers of the military space forces, although it is precisely they who ensure cosmodrome operation.

This idea, it would seem, was cast aside because it was unrealistic, but due to the project for construction of the international orbital station Alpha and the possibility of bringing the United States in as a stockholder it has surfaced again.

The time allocated for defining the specific leasing conditions will elapse after a month and the experts plan to meet once again in mid- February. Then only a few days will remain prior to the visit of Boris Yeltsin, president of the Russian Federation, to Kazakhstan and there is very little hope that during such a time it will be possible to arrive at a compromise.

The status of the problem of the demilitarization of Baykonur for the time being remains at the level "maybe yes - maybe no." It is evident that in such a case one of the sides must compromise. A more complex problem is that of the amount of lease payments. Here the requirements of Kazakhstan are extremely significant; the Kazakh negotiations are not about rubles, but about dollars.

In addition, the Kazakh side raised the question of compensation for its losses sustained due to the activity of Russia at the Baykonur cosmodrome and at three other test sites located in the territory of Kazakhstan. According to the calculations made by an unknown method the total cost of restoration associated with the operation of the Baykonur cosmodrome and three other test sites during 1992-1993 is more than 7 billion dollars. Meanwhile it has been established that harm to the health of the population has been inflicted only by nuclear tests at the Semipalatinsk test site. But since the moment that Russia proclaimed its sovereignty there has not been a single nuclear test there.

All this will probably soon force the directors of the Russian space branch to think seriously of the possibility of constructing a new spaceport in the Far East, the plan for which already exists.

Auction of Russian Space Items Criticized

947Q0085B Moscow ROSSIYSKIYE VESTI in Russian 1 Feb 94 p 5

[Article by K. Gerchik, V. Galyayev, V. Bryushinin, N. Lukovkin and V. Savinskiy, Council of Veterans of Baykonur Cosmodrome; "Space Mementos Under the Hammer"]

[Text] The veterans of the Baykonur cosmodromes were shocked by the news of the sale of mementos of our cosmonautics at the Sotheby's auction in London. The fact that today cosmonautics is in decline and Baykonur for the time being is in a deep crisis are not reasons for consigning our space achievements to oblivion. The auction which was held caused us a feeling of bitterness and bewilderment. And gave rise to many questions.

How could such a thing happen? Who gave permission for selling the national heritage of Russia? It is said that most of the 200 space rarities belonged to private parties. Is this so? But is the spacesuit of A. Leonov his own personal property? And the notebooks kept by S. Korolev and the manuscripts of K. Tsiolkovskiy? Whose

are they? Neither Korolev nor Tsiolkovskiy can any longer exert control over them. Who then put them up for sale?

At the auction Aleksey Leonov declared that the "history of Soviet cosmonautics should belong not only to the Russian people, but also to all world civilization." Yes, this is so. But is it necessary to sell our space mementos for this purpose? Was it not the pursuit of ready cash which darkened the reasoning of some Russian auction participants?

Throughout the world norms have been adopted with respect to the monuments of literature, history, science and technology. These norms also exist in Russia. For example, a project is underway for the facsimile publication of Pushkin's rough notebooks. This will make it possible not only to preserve for centuries a national treasure of Russia, but also will broaden the numbers of researchers concerned with research on the creativity of the great poet. Was it not possible to act in the same way with the manuscripts of Tsiolkovskiy, the diaries of Korolev, Mishin and Feoktistov? It also is possible to exhibit our space mementos abroad... Is this not an example of displaying and publicizing our attainments and a means for rectifying the sad situation of the former designers, cosmonauts and their families?

It seems to us that it is not only our cosmonautics which is in crisis, but also our moral values. After all, only this can explain the foreign sale of space vehicles, spacesuits and lunar ground by some space companies. This will scarcely save the space branch in Russia. And if we want to think about the future, a national space museum should be established.

Edict on Privatization of NPO Energiya

947Q0085C Moscow ROSSIYSKAYA GAZETA in Russian 9 Feb 94 p 4

[Article by B. Yeltsin, president, Russian Federation: "Decree on Privatization of Scientific Production Association imeni Akademik S. P. Korolev"]

[Text] Taking into account the special role of the Scientific Production Association (NPO) Energiya imeni S. P. Korolev in the implementation of the Russian Federal Space Program, I decree:

1. Adoption of the proposal of the Government of the Russian Federation on the formalization of federal ownership for three years of 51 percent of the ordinary shares in the privatization of the Russian Space Corporation Energiya imeni S. P. Korolev, established on the basis of the Scientific Production Association Energiya imeni Akademik S. P. Korolev.

2. This decree enters into force from the time of its publication.

[Signed] B. Yeltsin, president, Russian Federation, Moscow, the Kremlin, 4 February 1994, No 237

Lack of Agreement on Baykonur Threatens Cosmodrome's Capacities

947Q0087A Moscow NEZAVISIMAYA GAZETA in Russian 12 Feb 94 p 3

[Article by Liana Minasyan, under the rubric "Visit": "The Fate of Baykonur Could Be Decided in Moscow: The Negotiating Parties Should Speed Things Up"]

[Text] Winding up his trip to Kazakhstan, Andrey Kozyrev flew to Baykonur, whose fate is to be determined by an agreement that Moscow and Alma-Ata intend to sign when Nursultan Nazarbayev arrives.

Baykonur, which accounts for a third of all the country's space launches and from which all the manned programs are executed, has today become one of the most complicated problems in interstate relations. After receiving the ministry of foreign affairs, the Russian military—specifically, acting chief of the cosmodrome, Maj. Gen. Grafinin—assured him that the solution to the situation would be an agreement in which we leased, from Kazakhstan, the cosmodrome and the city of Leninsk, which covers 6,711 sq km of the Kzyl-Orda Oblast.

The cosmodrome can be saved—that is, not only its infrastructure of nine launch complexes and 15 launch pads designed to launch rockets ranging from the small Tsiklons to the superheavy Protons, but also its unique technologies and first-class specialists—only if it is operating, if there are launches. The military department wants guarantees of ownership of at least the shipments subsequent to 31 August 1991, which is when the cosmodrome was declared the property of Kazakhstan, because the organizations involved in executing space programs are feel apprehensive about participating in tests at Baykonur until its legal status is ascertained. Kazakhstan today, of course, is not in a position to maintain that monstrous complex, which takes R38 billion monthly to stay in operation.

To many, the creation of a Russian military base at Baykonur and the status of military specialists for the officers serving here seems an acceptable way out of the problem. But Kazakhstan could and apparently will insist on the demilitarization of the cosmodrome, and in Kiev, Nazarbayev suggested—the last time, not the first—the joint use of the cosmodrome. Be that as it may, the cosmodrome now exists in the territory of a different state, and the fact that Andrey Kozyrev in Alma-Ata was discussing humanitarian problems and questions of citizenship together with military agreements indicates that Russia and Kazakhstan cannot resolve their differences on each problem separately, but are linking them to military-political concessions they're making to each other.

But for now, the Russian military who are servicing Baykonur are still facing a legal case: operating here in the Russian military unit are organs of security transferred to the jurisdiction of Kazakhstan; in the city, there are two police forces, two courts—a Russian court and a

Kazakhstan court; for over a year now, according to the testimony of Maj.-Gen. Grafinin, there hasn't been a single draftee here, and as for contract workers, he has only 1,400 of the 8,600 he needs (local draftees—who are not citizens of Russia—cannot be brought here for contract labor). Meanwhile, the cosmodrome remains almost R11 billion in debt for construction and repairs, and it owes Kazakhstan R3 billion for electric power.

That is why the military department, threatening to disrupt even more the existing space programs, is insisting that the combat units stationed here be assigned status as Russian units and that the use of Baykonur and the city of Leninsk be stipulated in the leasing agreement.

Meanwhile, possibly the strongest impression on the cosmodrome is made by its satellite city—and that comes from the sharp contrast between, on the one hand, the grandiose cosmodrome structures and the world-class technologies used here and, on the other, the standard of living of those who service that space arch. Many officers are hurrying to take their families out of the city, which used to be under the special guardianship of Moscow and used to be a relatively pleasant "reservation" in an impoverished country. Now even the asceticism of the Soviet example cultivated in the armed forces cannot stop the grumbling among the military, many of whom—first-class specialists all—are making several times less than are their wives, who left for Russia. Those who remain are forced to resign themselves to periodic shutoffs of electricity and heat and to incredible prices in what is one of the most "expensive" cities. A recent survey of officers indicated that only 20 percent of them have agreed to continue their service according to the existing contract, 30 percent will do so on the condition that they receive a higher allowance, and the rest would prefer to leave the service. And that when the officer corps here is staffed at a 70-percent level, which forces them to work knowing that the production process is being violated. It needs to be borne in mind here that skills take years to get and are "passed on" literally from person to person. When the veterans complete their service and their work, that chain could be broken. The cosmodrome, over which Russia and Kazakhstan could be in difficult negotiations for many long years, could fall into disrepair by the time the negotiations are completed, and no one knows when it could be resuscitated or who could do it. The problem, obviously, is not only whether Russia is capable of executing ambitious space programs, but also whether it will be possible in the future to make up for the loss of the level of technology and skills that has been reached.

Russia-Kazakhstan Impasse on Baykonur Persists

947Q0087B Moscow SEGODNYA in Russian 16 Feb 94 p 2

[Article by Andrey Borodin, under the rubric "Problem": "Russia Is Doing Everything It Can To Maintain Baykonur: But The Cosmodrome Belongs, as Before, to a Foreign Power"]

[Text] The problem of the Baykonur rocket-and-space complex occupies a special place in Russian-Kazakhstan relations and has been under discussion for more than a year.

The military and diplomats of the Russian Federation are making titanic efforts to persuade Alma-Ata to sign a bilateral agreement for a lease of, preferably, 30 years and to recognize Baykonur as a Russian base, if only de facto.

But Kazakhstan authorities prefer a different version, one that is more attractive from their standpoint, one in which the cosmodrome could become a facility of multilateral cooperative efforts in which rich firms from the far-abroad could take part.

If that were to come about, it could take jobs away from Russian space generals, who, unlike the specialists of the middle and lower ranks, would have nothing to command. That is why the military are continuing to try to prove to Moscow—and to the head of the Ministry of Foreign Affairs, Andrey Kozyrev, who recently visited Baykonur—that the lease is the only acceptable version.

On the other hand, it's generally acknowledged that it is the Russian military who are maintaining the minimally required conditions for the operation of the extremely complicated assembly and testing complexes, the launch and firing centers, and the municipal and everyday services of the city of Leninsk, which has a population of 65,000.

Of the R47 billion allocated for maintaining the cosmodrome in 1993, the lion's share was released from the Russian Federation Ministry of Defense budget. The spending for 1994 has been set at five times more (in absolute figures), but the money promised is having a hard time making it to Baykonur.

In a 1992 interstate agreement, Russia assumed responsibility for 94 percent of the expenses for maintaining the complex, and Kazakhstan was obliged to pay the rest.

By the will of the fates, the main facility for basing the military-space forces of Russia is on foreign territory. But then it's hard to call Baykonur a facility—it's more like a small state within a state. There are almost 1,500 kilometers of roads running around the cosmodrome, and nearly 7,000 kilometers of power lines. The fixed assets of Baykonur are valued at nearly R4.5 trillion (at the prices for early 1994). Compared with that, the R56 billion spent on housing and municipal construction in Leninsk doesn't seem a very big amount. Occupying a big chunk of the Kazakh steppe with an area of approximately 50 x 110 km, the cosmodrome also controls huge tracts of land that are used as drop zones and right-of-way zones, and they're not only in Kazakhstan, but also in Russia, Turkmenia, and Uzbekistan.

From a juridical standpoint, not to mention from simply a human standpoint, the situation that has come to pass around Baykonur can only be called nonsense. In the city

and settlements around it, there are two police forces—one Russian, one Kazakh—and two court systems. True, there is still only one prosecutor's office, but because of confusion and the extremely complex living conditions, the staff members have announced a strike. In the words of the deputy chief of the cosmodrome, Maj.-Gen. Viktor Grafinin, the special conditions at the Baykonur facilities for the military-space forces of Russia that, for decades, were painstakingly hidden from "enemy eyes" are now being maintained by officers that are under Kazakhstan's jurisdiction, i.e., they are under the security service of a foreign country.

According to Gen. Grafinin, there were 22 launches of space vehicles with military and national-economy missions from Baykonur in 1992. In 1993, there were four. This year, they're still waiting for the first. The space industry is gradually falling into decline. Judging from what civilian and military specialists say, give it three—at best, five—years, and the process of decay will become irreversible: equipment will age, and the people will leave. The unique experience and knowledge garnered at the expense of tremendous money and effort will be left unused.

In the words of one Baykonur veteran who, over a 20-year period, rose from a worker to director of a large affiliate of NPO Energiya, the money that is being spent to mothball facilities and keep them in working order is fully comparable with the money that could produce an actual launch. In his opinion, three or four successful launches would be fully sufficient for attracting well-to-do clients who want to put their cargoes in orbit and for providing them safety guarantees. Moreover, the clients, in all likelihood, would want to be assured that the expensive equipment transported to the cosmodrome will not, one fine day, become someone else's property. That requires specific agreements between Moscow and Alma-Ata.

Kazakhstan's desire to get for Baykonur as much as possible and, hopefully, the "green stuff" is entirely normal. But Alma-Ata still needs to understand that Moscow is not in a position to pay sums that go beyond the bounds of common sense. Recent events around the long-suffering cosmodrome have shown that within the next two months, that issue will be resolved by the highest level, by the presidents of Russia and Kazakhstan.

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